DETERMINING THE FACTOR STRUCTURE OF AN INTEGRATED INNOVATION MODEL

Gurhan Gunday[1], Gunduz Ulusoy[1,·], Kemal Kilic[1] and Lutfihak Alpkan[2]

[1] Sabanci University, Faculty of Engineering and Natural Sciences,
34956 Orhanli-Tuzla, Istanbul, Turkey

[2] Gebze Institute of Technology, Department of Management,
41400 Cayirova Gebze-Kocaeli, Turkey

Abstract. This paper reports on elemental factor analyses of the innovativeness study in the Turkish manufacturing industry, drawing on a sample of 184 manufacturing firms. Factor structures are constructed in order to empirically test a framework identifying the relationships among innovativeness, performance and determinants of innovation. After several independent principal component analyses, factor structures of innovations, firm performance, organization culture, intellectual capital, manufacturing strategy, innovation barriers, and monitoring strategies are presented.

1. INTRODUCTION

This paper focuses on detecting the factor structures of variables in the integrated innovativeness model by means of several principal component analyses applied. Ultimately, our aim is to develop methods and strategies for modelling and analysis of innovativeness at the firm level, including its effect to the firm performance, based on an empirical study covering 184 manufacturing firms.

Multivariate data analysis, beginning by factor analyses, is used in order to discover important innovation determinants and to understand how innovations are produced at the firm level and revealing the main factors that shape an innovative atmosphere in manufacturing firms.

In order to collect the required data, we utilized an empirical survey. A questionnaire form has been developed to be filled in by the upper managers working in various enterprises of selected industries in order to assess the determinants of innovations and their structural associations to firm competitiveness and performance.

Factor analysis is a generic name given to a class of multivariate statistical methods whose main purpose is data reduction and summarization. It addresses the problem of analyzing the interrelationships among a large number of variables and then explaining these variables in

· Corresponding author. Tel.: +216 4839503; Fax: +216 4839550.
E-mail address: gunduz@sabanciuniv.edu
Updated Version November 26, 2013.

terms of their common factors. It is a technique particularly suitable for analyzing the complex, multidimensional problems encountered by researchers. It can be useful to observe the underlying patterns or relationships for a large number of variables and determine, if the information can be condensed or summarized in a smaller set of factors or components. The general purpose of factor analytic techniques is to find a way of condensing the information contained in a number of original variables into a smaller set of new composite dimensions (factors) with a minimum loss of information.

2. DATA

A questionnaire consisting of 311 individual questions was developed to be filled in by the upper managers of manufacturing companies. The questionnaire is designed to assess a firm's general characteristics, business strategies, intellectual capital, innovativeness efforts, competitive priorities, market and technology strategy, in-firm environment, market conditions and corporate performance. The initial survey draft was discussed with firms' executives and it was pre-tested by 10 pilot interviews to ensure that the wording, format and sequencing of questions are appropriate.

Data was collected over a 7-month period in 2006-2007 using a self-administered questionnaire distributed to firms' upper level managers operating in manufacturing sectors in the Northern Marmara region in Turkey. Because of the diversity of the organizational structures, where corporate strategies are developed, a manufacturing business unit was selected as the unit of analysis in the context of a developing country.

The firms are selected randomly from the database of the Union of Chambers and Commodity Exchange (TOBB), and from the chambers of industry located in the cities of Istanbul, Kocaeli, Sakarya, Tekirdağ, and Çerkezköy. The degree by how much the sample consisting of 184 firms is representative of the population is addressed by carrying out a series of comparative tests regarding firm distributions according to sectors. For each sector, number of firms in the sample turned out to be representative, since no significant difference ($p \leq 0.05$) has been detected between the population and sample percentages. Finally, out of 1674 questionnaires distributed, 184 useable forms are returned producing a response rate of about 11%.

Responding firms in our resulting sample are distributed among six main business sectors, namely automotive (20.1%), textile (19.6%), metal goods (19%), chemicals (17.9%), machinery (15.2%), and electrical home appliances (8.2%) industries. These industries were selected to represent the major manufacturing sectors in an emerging country such as Turkey. Responses are given by top managers (CEOs, general managers and owners; 33%), and middle managers (plant managers and functional managers; 67%).

Figure 1 depicts a profile of the resulting sample, illustrating its diversity in terms of annual sales volume, firm size (in terms of number of employees) and firm age. Firm size was determined by the number of full-time employees (up to 50: small, 50≤medium<250, ≥250: large) and firm age is determined by the year production started (up to 1975: old, 1975≤moderate<1992, ≥1992: young). Annual sales volume was divided into 5 categories namely <1M€, [1M€,5M€[, [5M€,20M€[, [20M€,50M€[and ≥50M€.

After the data collection stage, multivariate statistical analyses via SPSS v17 and AMOS v16 software package were conducted in order to validate the research framework. Occasional missing data were randomly distributed (MAR) on items.

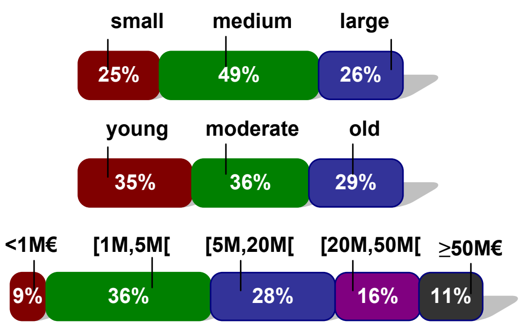

Figure 1: Sample Profile

3. RESEARCH MODEL

The innovation determinants can be grouped in two categories: indigenous and exogenous. The indigenous parameters include general firm characteristics (firm age, size, ownership status and foreign capital), firm structure (intellectual capital and organization culture), and firm strategies (such as collaborations, knowledge management, investments strategies and operations priorities). On the other hand, exogenous parameters are sector conditions (market structure, public regulations and incentives, and barriers to innovation). In a nutshell, innovativeness in a firm is a joint outcome, among others, firm strategies, organizational structure, its characteristics and external conditions. These innovation determinants with all their sub-elements are presented by an innovativeness model in **Figure 2**. Here, innovativeness is defined as a measure obtained by merging four innovation types performed, namely, product, process, marketing and organizational innovations.

The proposed innovation model reflects two stages. The first one is about the innovation process where innovation determinants constitute and determine the innovative capabilities of companies. The second stage is about how innovativeness influences a firm's performance. The model is built to investigate how certain factors called innovation determinants indeed determine the innovativeness level of a firm. We argue that in-firm and out-firm innovation determinants settle the innovative capability at that firm, which ultimately influences and affects the competitiveness of the firm in its marketplace, and hence, innovative financial, market, and production performance success of the company.

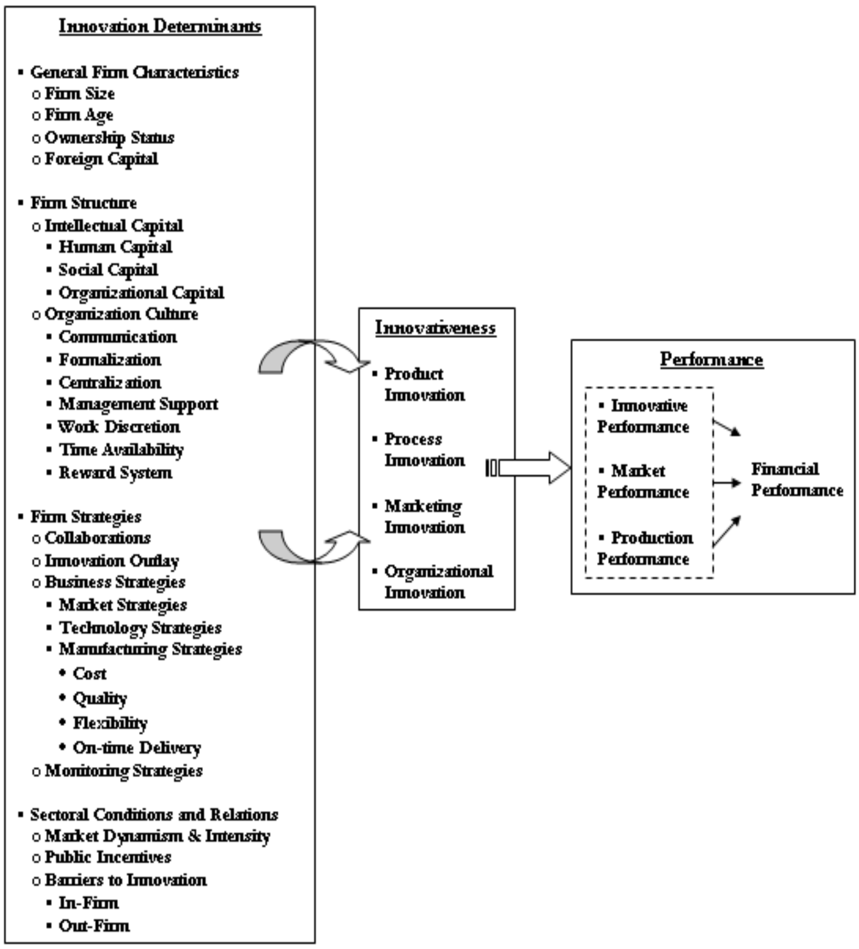

Figure 2: Integrated Innovativeness Model

4. PRINCIPAL COMPONENT ANALYSES

The first stage of multivariate data analysis started by extracting the factor structures of research framework. We aim to apply a principal component analysis (PCA) in order to reduce the larger sets of variables into a more manageable set of scales, since the initial number of variables is too large to conduct an analysis of individual linkages (Flynn et al., 1990; Benson et al., 1991; Saraph et al., 1989).

A PCA with varimax rotation is conducted to find out the underlying dimensions of determinants of innovations, innovations and firm performance. The title for each factor is selected to represent the included variables as closely as possible. This stage is concluded by exploring internal consistency and reliability (content validity) among the items of each construct via Cronbach α (Carmines and Zeller, 1979) and unidimensionality tests. Moreover, convergent validity between the innovation constructs is also examined and verified by the average-variance extracted (AVE) test, with its value being equal to the square root of average communalities of items on that factor (Fornell and Larker, 1981). A compelling demonstration of convergent validity would be an AVE score of 0.5 or above.

The purposes of factor analysis in this study are to explore how various items within each of the constructs (innovations, firm performance and innovation determinants) interact with one another; and to develop scales (by combining several closely correlated items) to be used in the following analysis on linkage (Kim and Arnold, 1996).

Factor analytic methods are useful to observe the underlying patterns or relationships for a large number of variables and they determine whether the information can be condensed or summarized in a smaller set of factors or components. Factors with eigenvalues (the amount of variance accounted for by a factor) larger than 1 were carried for further analysis (Kim and Mueller, 1978). Finally, extracted factors are controlled for normality, randomness and independency assumptions and thus data is validated for statistical tests. The scale value of each factor is determined by a simple average of the included items.

4.1 Innovations

For the PCA of firm performance (there are 24 items), Bartlett's test is conducted to assess the overall significance of the correlation matrix. As a result, the chi-square score is 2203.1 with $p<0.01$. Therefore we reject the null hypothesis that variables are uncorrelated in the population. Next, the KMO score is 0.901, which also validates that the correlation matrix is appropriate.

As a result of the PCA on innovations 4 factors are extracted. These four factors are respectively labeled based on the items included in each. The total variance explained is 59%. The Cronbach α values for the underlying factors range from 0.90 to 0.76 suggesting satisfactory levels of construct reliability, since for Cronbach α values greater than 0.70, the scale is accepted as reliable (Nunnally, 1978; Hair et al., 1998; Streiner, 2003).

Table 1 displays the results of PCA for innovations items. It is found that all factors have high (>0.45) loadings (Chin, 1998) and AVE scores for constructs range from 0.761 to 0.908 demonstrating discriminant validity.

4.1 Firm Performance

For the PCA of firm performance (there are 18 items), Bartlett's test chi-square score is 1692.9 with p<0.01. Therefore we reject the null hypothesis that variables are uncorrelated in the population. Next, the KMO score is 0.874, which also validates that the correlation matrix is appropriate.

PCA produced 4 factors, which explained 67% of the observed variance for firm performance. One of the innovative performance items, namely "ability to introduce new products and services to the market before competitors" is left outside the analysis as it is not categorized under an appropriate factor and failed the internal structure face validity check. Cronbach α for the underlying factors range from 0.93 through 0.71 again indicating reliability of factors.

Table 2 displays the results of PCA for performance items. It is found that all factors have high (>0.45) loadings and AVE scores for constructs range from 0.761 to 0.908 demonstrating discriminant validity.

Table 1: PCA of Innovations

Factors	Factor Loads	Eigen-value	Cum. % variance explained	Cronbach α	AVE
Factor 1: Organizational Innovations		8.982	37.425	0.896	0.761
Renewing the organization structure to facilitate teamwork.	0.763				
Renewing the production and quality management systems.	0.754				
Renewing the organization structure to facilitate coordination between different functions such as marketing and manufacturing.	0.722				
Renewing the routines, procedures and processes employed to execute firm activities in innovative manner.	0.719				
Renewing the human resources management system.	0.682				
Renewing the supply chain management system.	0.672				
Renewing the organization structure to facilitate project type organization.	0.664				
Renewing the in-firm management information system and information sharing practice.	0.584				
Renewing the organizational structure to facilitate strategic partnerships and long-term business collaborations.	0.456				
Factor 2: Marketing Innovations		2.160	46.425	0.833	0.767
Renewing the product promotion techniques employed for the promotion of the current and/or new products.	0.748				
Renewing the distribution channels without changing the logistics processes related to the delivery of the product.	0.730				
Renewing the product pricing techniques employed for the pricing of the current and/or new products.	0.660				
Renewing the design of the current and/or new products through changes such as in appearance, packaging, shape and volume without changing their basic technical and functional features.	0.658				
Renewing general marketing management activities.	0.599				
Factor 3: Process Innovations		1.795	53.903	0.819	0.811
Determining and eliminating non value adding activities in delivery related processes	0.731				
Decreasing variable cost and/or increasing delivery speed in delivery related logistics processes.	0.726				
Increasing output quality in manufacturing processes, techniques, machinery and software.	0.655				
Decreasing variable cost components in manufacturing processes, techniques, machinery and software.	0.635				
Determining and eliminating non value adding activities in production processes	0.543				
Factor 4: Product Innovations		1.229	59.023	0.758	0.750
Developing new products with technical specifications and functionalities totally differing from the current ones.	0.708				
Developing newness for current products leading to improved ease of use for customers and to improved customer satisfaction.	0.706				
Developing new products with components and materials totally differing from the current ones.	0.623				
Decreasing manufacturing cost in components and materials of current products	0.540				
Increasing manufacturing quality in components and materials of current products	0.455				

K-M-O Measure of Sampling Adequacy = 0.901; Bartlett Test of Sphericity = 2203.1; p<.000.

Table 2: PCA of Firm Performance

Factors	Factor Loads	Eigen-value	Cum. % variance explained	Cronbach α	AVE
Factor 1: Financial Performance		5.998	35.282	0.930	0.788
Return on assets (profit/total assets).	0.918				
General profitability of the firm.	0.910				
Return on sales (profit/total sales).	0.893				
Cash flow excluding investments.	0.777				
Factor 2: Innovative Performance		2.588	50.506	0.816	0.908
Renewing the administrative system and the mind set in line with firm's environment.	0.755				
Innovations introduced for work processes and methods.	0.736				
Quality of new products and services introduced.	0.701				
Number of new product and service projects.	0.657				
Percentage of new products in the existing product portfolio.	0.651				
Number of innovations under intellectual property protection.	0.562				
Factor 3: Production Performance		1.676	60.362	0.711	0.824
Production (volume) flexibility.	0.729				
Production and delivery speed.	0.697				
Production cost.	0.677				
Conformance quality.	0.661				
Factor 4: Market Performance		1.152	67.136	0.766	0.764
Total sales	0.729				
Market share	0.727				
Customer satisfaction	0.606				
K-M-O Measure of Sampling Adequacy = 0.839; Bartlett Test of Sphericity = 1692.9; *p*<.000					

4.2 Manufacturing Strategy

For the PCA of operations priorities (there are 25 variables), Bartlett's test chi-square score is 1557.1 and p<0.01. Therefore we reject the null hypothesis that variables are uncorrelated in the population. Next, the KMO score is 0.838, which also validates that the correlation matrix is appropriate (**Table 3**).

After omitting five variables whose communalities are below 0.5, PCA produced 4 factors with latent root criterion which explained 61% of the observed variance for manufacturing strategy and the average of communalities was 0.601. The omitted variables are: "Decrease in the number of product returns from the customers", "Decrease in the personnel costs", "Increase in the personnel capabilities for different tasks", "Minimize the difficulties with deliveries" and "Increase the flexibility of changing business priorities according to incoming orders". It is found that all factors have high (>0.45) loadings, also to validate the factors, we look at the AVE tests and Cronbach α values. Here, the smallest AVE score for the underlying factors is 0.750 and Cronbach α values range from 0.843 to 0.770, suggesting satisfactory levels of construct reliability.

Table 3: Manufacturing Strategy

Factors	Factor Loads	Eigen-value	Cum. % variance explained	Cronbach α	AVE
Factor 1: Cost Efficiency		6.423	32.114	0.843	0.750
Decrease in total cost of manufacturing processes	0.763				
Decrease in total cost of internal and external logistics processes	0.738				
Decrease in operating costs	0.728				
Increase in personnel productivity	0.686				
Decrease in input costs	0.644				
Decrease in waste and scrap	0.579				
Decrease in defective intermediate and end products	0.558				
Factor 2: Dependability/Delivery		2.454	44.385	0.823	0.805
Increase in delivery speed of products	0.788				
Decrease the makespan from start of manufacturing process to the end of delivery	0.744				
Increase in ability to meet the delivery commitments	0.718				
Decrease the makespan from taking the orders to the end of delivery	0.707				
Increase in just in time delivery	0.631				
Factor 3: Flexibility		1.708	52.927	0.796	0.759
Increase in ability of flexible use of current personnel and hardware for non-standard products	0.826				
Increase in ability of producing non-standard products	0.799				
Decrease in declining product orders with different specifications	0.720				
Ability to change machines and equipments priorities when necessary	0.657				
Increase in ability of flexible production	0.484				
Factor 4: Quality		1.426	60.058	0.770	0.806
Increase in product and service quality according to customers' perception	0.809				
Increase in product and service quality compared to rivals	0.782				
Decrease in customer complaints	0.725				
KMO Measure of Sampling Adequacy = 0.838; Bartlett Test of Sphericity = 1557.1; *p*<.000.					

4.3 Intellectual Capital

For the PCA of 14 intellectual capital items, Bartlett's test chi-square score is 1093.8 with $p<0.01$. Therefore we reject the null hypothesis that variables are uncorrelated in the population. Next, the KMO score is 0.870, which also validates that the correlation matrix is appropriate. PCA produced 3 factors, which explained 60% of the observed variance for firm performance. Cronbach α for the underlying factors range from 0.84 through 0.73 again indicating reliability of factors.

Table 4 displays the results of PCA for performance items. It is found that all factors have high (>0.45) loadings and AVE scores for constructs range from 0.756 to 0.793 demonstrating discriminant validity.

Table 4: Intellectual Capital

Factors	Factor Loads	Eigen-value	Cum. % variance explained	Cronbach α	AVE
Factor 1: Human Capital		5.633	40.238	0.838	0.793
Our human resources are very intelligent and creative	0.825				
Our human resources are very talented	0.801				
Our human resources are best performers	0.726				
Our human resources are specialized on their jobs	0.669				
Our human resources are producing new ideas and knowledge	0.633				
Factor 2: Social Capital		1.607	51.716	0.790	0.756
Communication and knowledge sharing is high between employees from different departments	0.822				
Knowledge sharing and learning from each other is very common from employees from same department	0.792				
Regular collaboration exists for problem/opportunity detection and resolution between our employees	0.642				
Frequent collaboration exists for problem/opportunity detection and resolution between our employees and customers/suppliers.	0.535				
Our employees may use their job expertise on specified subject on another field for problem/opportunity detection and resolution.	0.466				
Factor 3: Organization Capital		1.215	60.395	0.726	0.783
Our corporate knowledge accumulation is reflected on all corporate systems and processes.	0.827				
Our corporate business methods are interiorized to our employees via corporate culture means (leaders, meetings, slogans, celebrations, etc.).	0.772				
We are recording our knowledge accumulation on databases and manuscripts.	0.765				
We are taking patents, licenses etc. in order to protect all our original knowledge accumulation.	0.507				

KMO Measure of Sampling Adequacy = 0.870; Bartlett Test of Sphericity = 1093.8; $p<.000$.

4.4 Organization Culture

For the PCA of 40 organization culture items, Bartlett's test chi-square score is 4107.0 with p<0.01. Therefore we reject the null hypothesis that variables are uncorrelated in the population. Next, the KMO score is 0.868, which also validates that the correlation matrix is appropriate.

PCA produced 7 factors, which explained 63% of the observed variance for firm performance. Cronbach α for the underlying factors range from 0.92 through 0.74 again indicating reliability of factors.

Table 5 displays the results of PCA for performance items. It is found that all factors (but two) have high (>0.45) loadings and AVE scores for constructs range from 0.750 to 0.867 demonstrating discriminant validity.

Table 5: Organization Culture

Factors	Factor Loads	Eigen-value	Cum. % variance explained	Cronbach α	AVE
Factor 1: Management Support		12.372	30.931	0.899	0.750
The development of new and innovative ideas are encouraged	0.702				
In my organization, developing one's own ideas is encouraged for the improvement of the corporation.	0.656				
Senior managers encourage innovators to bend rules and rigid procedures in order to keep promising ideas on track.	0.645				
Every employee is willing to develop new ideas and projects.	0.638				
It is encouraged that employees from different department come together to develop new project ideas.	0.613				
Upper management is aware and very receptive to my ideas and suggestions	0.593				
Money is often available to get new project ideas off the ground	0.568				
Employees can easily reach necessary information to do their job.	0.515				
There are several options within the organization for individuals to get financial support to actualize their innovative projects	0.506				
Individual risk takers are often recognized for their willingness to champion new projects, whether eventually successful or not.	0.503				
The term risk taker is considered a positive attribute for people in my work area	0.455				
Factor 2: Reward System		3.283	39.139	0.920	0.860
Employees with innovative and successful projects will be highly rewarded.	0.792				
The rewards that employees received or will receive are dependent on their work on the job.	0.782				
Employees from every level will be rewarded, if they innovate	0.773				
Employees will be appreciated by their managers if they perform very well.	0.770				
Managers increases employee's job responsibilities if they perform well	0.736				
Factor 3: Centralization		2.654	45.773	0.850	0.797
Decision making incentives are limited for middle and upper level employees	0.779				
Authority for making decisions on even insignificant issues rests with the senior management	0.767				
Routine decision making and daily tasks require approval from upper level managers	0.745				
Middle and lower level employees are not encouraged to take initiative	0.741				
Middle level managers are not given initiative in the management of processes and tasks	0.632				

Decisions are generally made at the upper levels of the organizational hierarchy	0.570				
Factor 4: Formalization		2.089	50.995	0.735	0.755
Employees seek assistance for decision making in documents such as organization handbook, procedures and manuals	0.726				
Employees consider our company as a completely institutionalized entity	0.678				
Employees have written and clear job descriptions	0.581				
Employees are not allowed to develop their own rules while conducting their work	0.578				
Employees are monitored constantly whether the initiatives they take violate the corporate rules and procedures	0.569				
Daily applications are expected to be compatible with the standard task procedures	0.431				
Factor 5: Communication		1.718	55.289	0.797	0.802
Employees are asked for their ideas and feedbacks on major changes	0.677				
Employees are informed on major changes	0.657				
Communication channels are open between upper levels of management and the employees	0.653				
Employees are informed on corporate plans	0.613				
Communication channels are open among the employees at the same level of hierarchy	0.572				
Factor 6: Time Availability		1.646	59.403	0.867	0.867
I always seem to have plenty of time to get everything done	0.825				
I have enough time to spend for developing new ideas.	0.827				
I have just the right amount of time and work load to do everything well.	0.738				
Factor 6: Work Discretion		1.253	62.536	0.752	0.777
I have the freedom to implement different work methods for doing my major and routine tasks from day to day.	0.738				
It is basically my own responsibility to decide how my job gets done.	0.697				
This organization provides freedom to use my own judgment and methods	0.578				
I have the freedom to decide how to execute my job.	0.428				
KMO Measure of Sampling Adequacy = 0.868; Bartlett Test of Sphericity = 4107.1; *p*<.000.					

4.5 Innovation Barriers

For the PCA of 29 barriers of innovation items, Bartlett's test chi-square score is 2453.5 with $p<0.01$. Therefore we reject the null hypothesis that variables are uncorrelated in the population. Next, the KMO score is 0.857, which also validates that the correlation matrix is appropriate.

PCA produced 5 factors, which explained 60% of the observed variance for firm performance. Cronbach α for the underlying factors range from 0.87 through 0.78 again indicating reliability of factors.

Table 6 displays the results of PCA for performance items. It is found that all factors (but 1) have high (>0.45) loadings and AVE scores for constructs range from 0.84 to 0.73 demonstrating discriminant validity.

Table 6: Innovation Barriers

Factors	Factor Loads	Eigen-value	Cum. % variance explained	Cronbach α	AVE
Factor 1: Internal Resistance		8.742	31.222	0.872	0.759
Corporate climate is not suitable for innovation	0.800				
The company does not value continuous improvement	0.752				
Resistance to innovativeness in the workplace	0.721				
Upper level managers are faulty/slow in their approval process	0.720				
Lack of clarity in the goals of innovation projects	0.654				
Lack of supervision on innovation processes	0.654				
Lack of strategy based on innovation processes	0.648				
Excessive monotonous and routine workload	0.503				
Factor 2: Internal Deficiency		3.086	42.241	0.874	0.840
Insufficient technical experience	0.832				
Insufficient technical knowledge	0.800				
Insufficient number of qualified personnel	0.746				
Difficulty in finding/hiring qualified personnel	0.602				
Lack of qualified R&D manager	0.598				
Factor 3: Internal Limitations		1.846	48.835	0.795	0.762
High costs of innovation	0.729				
Insufficient financial resources	0.711				
High risks associated with innovation	0.645				
Time constraints for intrafirm technological development	0.580				
Lack of organization for technology transfer	0.555				
Factor 4: External Difficulties		1.782	55.198	0.775	0.730
Difficulty in obtaining the required material, parts, or equipment	0.813				
Deficiency in acquiring technological services obtained from third party resources (technical and scientific consultation, auditing, inspection, standards, etc.)	0.798				
Simultaneous execution of several innovation projects	0.548				
Loopholes in the protection of intellectual property rights	0.540				
Difficulty in accessing technological information resources	0.533				
Difficulty in customer's adaptation to new product	0.420				
Factor 5:External Limitations		1.252	59.671	0.784	0.786
Constraints resulting from laws, regulations and standards	0.788				
Difficulty in cooperating with other companies and public research centers	0.630				
Insufficient government support and incentives	0.635				
Difficulty in acquiring external financing	0.532				

KMO Measure of Sampling Adequacy = 0.857; Bartlett Test of Sphericity = 2453.5; *p*<.000.

4.6 Monitoring

For assessing the monitoring activities of firms sampled it was asked how frequently the companies monitor various information/knowledge sources concerning developments in the innovation scene. For the PCA of 12 monitoring items, Bartlett's test chi-square score is 501.2 with $p<0.01$. Therefore we reject the null hypothesis that variables are uncorrelated in the population. Next, the KMO score is 0.799, which also validates that the correlation matrix is appropriate.

PCA produced 3 factors, which explained 53% of the observed variance for firm performance. Cronbach α for the underlying factors range from 0.688 through 0.655 again indicating reliability of factors.

Table 7 displays the results of PCA for performance items. It is found that all factors have high (>0.45) loadings and AVE scores for constructs range from 0.777 to 0.702 demonstrating discriminant validity.

Table 7: Monitoring

Factors	Factor Loads	Eigen-value	Cum. % variance explained	Cronbach α	AVE
Factor 1: Monitoring Outer Milieu		3.876	32.302	0.665	0.702
Universities	0.793				
Companies from other industries	0.632				
Benchmarking	0.623				
Published patents	0.524				
Factor 2: Monitoring Inner Milieu		1.296	43.099	0.655	0.717
Customers	0.694				
Suppliers	0.659				
Dealers/Vendors	0.651				
Exhibitions	0.552				
Competitors	0.506				
Factor 3: Monitoring Open Innovation Resources		1.184	52.967	0.688	0.777
Internet and e-databases	0.762				
Scientific and technical publications	0.665				
Scientific and professional meetings	0.543				
KMO Measure of Sampling Adequacy = 0.799; Bartlett Test of Sphericity = 502.2; *p*<.000.					

4.7 Collaborations

There are three collaboration factors. These factors include several collaboration types given as in **Table 8**.

4.8 Second Order PCA of Innovation Determinants

Table 9 illustrates the results of the second order PCA for innovation determinants. For this analysis all the innovation determinant constructs are entered to the principal component analysis and five factors are extracted. The total variance explained is 58%. It is found that all the items have high (>0.40) loadings, but only four of them remain reliable regarding their Cronbach α value. Except collaboration factor, whose α value is 0.51, the Cronbach α values range from 0.81 to 0.72.

Table 8: Collaborations

R&D Collaborations	Vertical Collaborations	Operational Collaborations
Collaboration with research centers & universities	**Collaboration with suppliers**	**Production collaboration**
Collaboration with competitors	**Collaboration with customers**	**Purchasing collaboration**
Collaboration with other firms (other than suppliers and customers)		**Service/delivery/sales collaboration**
		Training collaboration
		Completing collaboration

Bartlett's test chi-square score is 1430 with $p<0.01$. Therefore we reject the null hypothesis that variables are uncorrelated in the population. Next, the KMO score is 0.803, which also validates that the correlation matrix is appropriate.

Table 9: Second Order PCA of Innovation Determinants

Factors	Factor Loads	Eigen-value	Cum. % variance explained	Cronbach α
Factor 1: Firm Culture		5.743	26.105	0.810
Work discretion	0.807			
Management support	0.740			
Centralism (r)	0.719			
Reward system	0.701			
Communication	0.647			
Time availability	0.407			
Factor 2: Innovation Barriers		2.579	37.827	0.801
Internal deficiency	0.775			
External limits	0.770			
External difficulties	0.751			
Internal limits	0.704			
Internal resistance	0.573			
Factor 3: Firm Manufacturing Strategy		1.827	46.133	0.723
On-time delivery	0.797			
Cost	0.746			
Flexibility	0.714			
Quality	0.660			
Factor 4: Intellectual Capital		1.390	52.453	0.746
Formalism	0.782			
Organization capital	0.680			
Social capital	0.529			
Human capital	0.402			
Factor 5: Collaboration		1.196	57.888	0.510
Vertical collaborations	0.784			
Operational collaborations	0.637			
R&D collaborations	0.571			

K-M-O Measure of Sampling Adequacy = 0.803; Bartlett Test of Sphericity= 1429,964, p<.000

5. CONCLUSIONS

This paper reports on elemental factor analyses of the innovativeness study in the Turkish manufacturing industry, drawing on a sample of 184 manufacturing firms. Factor structures are constructed in order to empirically test a framework identifying the relationships among innovativeness, performance and determinants of innovation.

After several independent principal component analyses, factor structures of innovations, firm performance, organization culture, intellectual capital, manufacturing strategy, innovation barriers, and monitoring strategies are presented.

REFERENCES

Benson, P.G., Saraph, J.V., Schroeder, R.G., 1991. The effects of organizational context on quality management: an empirical investigation. Management Science, 7 (9), 1107-1124.

Carmines, E.G., Zeller, R.A., 1979. Reliability and Validity Assessment, Sage, Newbury Park, CA.

Chin, W.W, 1998. Issues and opinion on structural equation modeling. MIS Quarterly 22 (1), 7-16.

Flynn, B.B., Sakakibara, S., Schroeder, R.G., Bates, K.A., Flynn, E.J., 1990. Empirical research methods in operations management. Journal of Operations Management, 9 (2), 250-284.

Fornell, C., Larker, D.F., 1981. Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. Journal of Marketing Research, 18 (February), 39-50.

Hair, J.F., Anderson, R.E., Tatham, R.L., Black, W.C., 1998. Multivariate Data Analysis. Prentice-Hall, NJ.

Kim, J.S., Arnold, P., 1996. Operationalizing manufacturing strategy. International Journal of Operations & Production Management, 16 (12), 45-73.

Kim, J.O., Mueller, C.W., 1978. Introduction to Factor Analysis, Sage, Newbury Park, CA.

Nunnally, J.C., 1978. Psychometric Theory. McGraw-Hill, New York, NY.

Saraph, J.V, Benson, P.G., Schroeder, R.G., 1989. An instrument for measuring the critical factors of quality management. Decision Sciences, 20 (4), 810-812.