Innovation Clusters and Determinants of Innovativeness in Manufacturing Industries

Mete Sevinç
Department of Industrial Engineering
Eindhoven University of Technology
Eindhoven, The Netherlands
m.sevinc@tue.nl

Gündüz Ulusoy
Faculty of Engineering and Natural Sciences
Sabancı University
Istanbul, Turkey
gunduz@sabanciuniv.edu

***Abstract*— Innovation is an important source of competitiveness and is studied extensively by both the academicians and the practitioners particularly in the last decades. This study is based on the results of an exploratory study conducted in the Northern Marmara region of Turkey covering 184 manufacturing firms. A model is developed to determine the determinants of innovativeness and data is gathered through a questionnaire to validate this model. The resulting determinants of innovativeness are intellectual capital, organizational structure, organizational culture, manufacturing strategy, barriers to innovation, and collaborations. As a result of cluster analysis employing the same dataset, four innovation clusters are obtained using five innovation types: Radical product innovation, incremental product innovation, process innovation, marketing innovation, and organizational innovation. These clusters are labeled as the Leading innovators, Followers, Inventors, and Laggers. In this study, we test the hypothesis that different innovation clusters put different emphasis on different determinants of innovativeness as well as on different components of these determinants. The hypotheses are all supported except for organizational culture and collaborations. These results together with those associated with the components of the determinants are commented upon.**

Keywords—statistical analysis; innovation; innovativeness; manufacturing industry.

I. INTRODUCTION

The success and survival of organizations in today's world depend on their creativity, innovation, discovery and inventiveness. The early examples of innovation present themselves in the shape of inventions, such as the watermill, the printing press and the wheel. Many gadgets invented throughout the existence of human kind had only one major purpose to fulfill, and that was to make life easier for humanity. Today the significance of innovation in our lives and in economy in general is better understood and appreciated. The concept took on a fresh understanding. Innovation is not anymore the concern of a small group in an organization but is considered to be all pervasive. More and more we observe open innovation networks. Continuous innovation today is essential for the survival of organizations. It has become an integral part of our lives, as we greatly benefit from direct results of innovation in the shape of products and services we use every day. The pace of innovation has been increasing over time particularly over the last decades. The disruptive nature of innovation is more frequently observed in business life today.

One of the earlier definitions by Schumpeter [1] described innovation as the introduction of new goods, new methods of production, the opening of new markets, the conquest of new sources of supply and the carrying out of a new organization in any industry. Drucker [2] stated that innovations are extremely vital for perpetual success and are located in the heart of the entrepreneurial companies that seek further profitability and competitiveness and described it as the effort to create purposeful, focused change in an enterprise's economic or social potential.

The innovation perception to be used in this study is closest to the definitions introduced by the European Commission reports [3], explaining the characteristics of innovation in three clauses: A radical or marginal extension or update on the range of products, services or markets; development of new methods for production, acquisition and distribution; implementation of new techniques that increase the utilization of manpower, the organization, the work conditions, and the administration.

978-1-4673-7762-1/16/$31.00 ©2016 IEEE

OECD Oslo Manual [4] is the primary international basis of guidelines for defining and assessing innovation activities as well as for the compilation and use of related data. Here, it has been taken as the fundamental reference source to describe, identify and classify innovations at firm level. In the OECD Oslo Manual, four different innovation types are introduced. These are product innovation, process innovation, marketing innovation, and organizational innovation. Here, we classify product innovation further as incremental and radical product innovations. Product and process innovations are referred to usually as technological innovations whereas marketing and organizational innovations as non-technological innovations. In the last decades, the contribution of non-technological innovations to the performance of organizations is appreciated more.

This study is based on the results of an exploratory study conducted in the Northern Marmara region of Turkey covering 184 manufacturing firms. A model is developed to determine the determinants of innovativeness and data is gathered through a questionnaire to validate this model. The resulting determinants of innovativeness obtained through structural equation modeling (SEM) approach are intellectual capital, organizational structure, organizational culture, manufacturing strategy, barriers to innovation, and collaborations [5]. For the purposes of this study, we will not include manufacturing strategy determinant in the analysis because it has already been investigated in an earlier study [6].

As a result of cluster analysis employing the same data set, four innovation clusters are obtained using five innovation types: Radical product innovation, incremental product innovation, process innovation, marketing innovation, and organizational innovation. These clusters are labeled as the Leading innovators, Followers, Inventors, and Laggers [6]. In this study, we test the hypothesis that different innovation clusters put different emphasis on different determinants of innovativeness as well as on different components of these determinants. There are in total 18 components.

In the following section, the determinants of innovativeness model is briefly introduced. In the third section, innovation clusters emerging from this same data set are presented. Research question and hypothesis statement constitute the fourth section. Hypothesis test results for the determinants of innovations are given in section five followed by the mean comparison results of the innovation clusters for the individual determinants in the following four sections. The paper concludes in section ten.

II. THE DETERMINANTS OF INNOVATIVENESS MODEL

After an extensive literature survey the determinants of innovativeness are classified in two subgroups: in-firm (indigenous) determinants and out-firm (exogenous) determinants. The indigenous determinants include general firm characteristics (age, size, foreign capital and legal status), firm structure (intellectual capital, organizational structure, organizational culture), firm strategies (market, technology, and manufacturing strategies), barriers to innovation, monitoring, innovation outlay, and collaborations. On the other hand, exogenous determinants are identified as industrial conditions and relations.

We will now briefly introduce some of the above determinants, which are employed in this study.

A. *Intellectual Capital*

Intellectual capital can be defined as the total stocks of all kinds of intangible assets, knowledge, capabilities, and relationships, etc., at employee level and organization level within a company and has attracted much attention in the innovation literature [7]. It is examined under three subgroups: namely, human, social, and organizational capital. The human capital is the sum of knowledge and skills that can be improved especially by training and work experience of the employees of an organization [8,9]. The social capital is the knowledge embedded within, available through and utilized by interactions among individuals and their networks of interrelationships [10]. Organizational capital is the institutionalized knowledge and codified experience residing within and utilized through databases, patents, manuals, structures, systems, and processes [11].

B. *Organizational Structure*

Centralization, formalization, and communication are the components of the organizational structure determinant. Centralization implies concentration of the decision making power at the top of an organizational hierarchy. It is expected to have a negative impact on innovativeness, if overdone. Formalization, on the other hand, can be described as the extent to which work roles are structured and the activities of the employees are governed by rules and procedures. It is an essential management tool for securing a formal structure but care should be exercised not to give up on the flexibility and agility of the organization. Exchange of information, mutual understanding and shared meaning among members of the organization constitute the basis for communication. As argued above innovation requires low formalization and centralization, but higher levels of internal communication [12].

Accordingly an organic structure fosters innovation that enables a participatory inner environment where market and technical information and decision making authority are distributed to lower levels and where strict rules do not govern experimentation and trial efforts ([13], [14]).

C. Organizational Culture

Organizational culture is becoming increasingly more recognized for its key role in managing innovation [15]. Components of organizational culture considered here are managerial support, reward system, work discretion and time availability. A suitable environment for innovativeness, which is especially related to intrapreneurship, i.e., entrepreneurship and innovativeness at the individual employee level, can be shaped by some managerial arrangements, such as management support for generation of new ideas, allocation of time availability, work discretion, appropriate use of incentives and rewards, and tolerance for failures in creative undertakings and risky innovation projects ([16], [17], [18], [19], [20], [21], [22]). In this respect, encouragement of new idea generation and development is expected to positively influence a firms' entrepreneurial behavior and enhance potential intrapreneurs' perceived trustworthiness to their organizations in terms of detecting opportunities and willingness to develop novel or useful ideas and/or projects and to take risks to actualize them [23]. Availability of free time for employees is another critical factor for their both daily routines and intrapreneurial ideas and activities, i.e., time to imagine, observe, experiment and develop (e.g., [24], [25]) since most of the enthusiastic intrapreneurs make their pioneering steps to actualize their idealized projects in their spare time [26].

Moreover, autonomous work arrangements such as work discretion i.e., ability to take initiative in decision making and planning flexibility, i.e., the ability to revise plans in order to cope with rapid environmental changes leading to a higher degree of organizational adaptability are assumed to increase the speed and effectiveness of the innovative processes and then the organizational performance in general (e.g., [27], [28]). Additionally, if the employees have a high level of trust in the reward system of their organization and also feel free from punishment, adverse criticism, or loss of support in case of failure of their projects or ideas, then their commitment to innovative attempts will be increased (e.g., [29], [30]).

D. Barriers to Innovation

Barriers to innovation can have its sources within the organization as well as outside the organization. Internal resistance - one of the components- can be caused by factors such as lack of strategy based on innovation processes, lack of clarity in the goals of innovation projects, corporate climate not being suitable for innovation. Two further components are internal limitations (such as time and financial limitations, higher risk and cost of innovation) and internal deficiency (lack of technical information and experience, lack of qualified employee and lack of qualified R&D manager, etc.). Components, which are considered to be exogenous, are external limitations (such as limited funding, lack of motivating governmental regulations, etc.) and external difficulties (such as difficulties of finding necessary components, materials, technological services, difficulty of adopting new products by customers, etc.).

It has been interesting to observe that managers mostly complain about external components of barriers to innovation rather than internal components [5]. This is an interesting but familiar observation. For example, when trying to implement a change process in an organization such as Total Quality Management, managers at all levels of the organization tend to put the blame on exogenous rather than indigenous factors.

E. Collaborations

The determinant of innovativeness designated as collaborations has three components: R&D collaboration, vertical collaboration, and operational collaboration. R&D collaborations involve cooperation of firms with the third party research centers and universities, as well as with their competitors and firms from other industries. Vertical collaborations necessitate working closely with the suppliers and the customers in order to strengthen the supply chain. Lastly, operational collaborations require teamwork in vital operations in terms of production, purchasing, service/delivery/sales, staff education and staying ahead of competition. Such collaborations not only contribute to the competitiveness of the companies but also serve as a source of innovative ideas. The results reported in [5] suggest that collaboration has significant effect on innovativeness; hence, it is a factor to which upper management should not turn a blind eye. In that sense, collaborations, particularly R&D collaborations, which are least utilized by the companies, are open for significant improvements in a company so that such a policy can lead to a more innovative environment.

III. DATA GATHERING

For testing the determinants of innovativeness model a questionnaire with 311 individual questions was prepared and submitted to upper managers of manufacturing companies in 6 distinct industries: textile, chemical, metal products, machinery, domestic appliances and automotive industries. The initial survey went through a pilot study consisting of 10 interviews to test formatting, wording and sequencing of the questions. Further information on data gathering stage can be found in [31].

The data set was obtained over a 7-month period. As a result of the diversity of the organizational structures, manufacturing business unit was selected as the unit of analysis. A total of 1674 firms were randomly selected in accordance with the total number of firms in each sector and province covered by the study. 184 useful questionnaires were obtained, resulting in a response rate of 11%. All the respondents completing the questionnaire were from the top (52%) or middle management (48%). Firm size was determined by the number of full-time employees (up to 50: small; between 50 and 250: medium; more than 250: large) and the firm age was determined by the year the firm started production (earlier than 1975: old; between 1975 and 1992: moderate; younger than 1992: young). Missing data points were handled by the random distribution (MAR) on items and were deleted by list-wise deletion. Concerning the control variables investigated (age, size, foreign capital and legal status) no statistical evidence for significance was detected. The distribution of industries on the data set ended up as; Textile (19.6%), Chemical (17.9%), Metal (19%), Machine Industry (15.2%), Domestic Appliances (8.2%), Automotive (20.1%). For each sector, the number of firms in the sample emerged as representative since no significant difference has been detected between the population and sample percentages.

The questionnaire form was prepared by considering recent questionnaire forms utilized in similar studies and commonly accepted measures met in the current literature. Specifically, the questions about manufacturing strategy, organizational structure and culture, innovation barriers, intellectual capital, business strategies were enquired using a 5-point Likert scale and inquiring how important each item is for the firm with the scale ranging from 1=extremely unimportant to 5=extremely important. Such subjective measures possibly bring in manager bias, but are widespread practice in empirical research [15].

The scales of the four different manufacturing strategies' measures were adapted from the existing operations management (OM) literature with six, six, seven, and six criteria, respectively. The base of items asked regarding these priorities were adapted mainly from [32], [33], [34], [35], [36], and [37]. For business strategy items, we also benefited from [38].

The scales of the three intellectual capital measures were constructed by inspiring from [39] with five, five, and four criteria, respectively for the human capital, social capital and organizational capital. Similarly, organizational structure and organizational culture measures were adapted from several criteria in the OM literature based on previous studies [40], [41], and [42].

The questions about innovative capabilities were enquired employing a 5-point Likert scale. The respondents were asked to indicate “to what extent are the related applications/practices implemented in your organization in the last three years” ranging from 1=‘not implemented’, 2=‘imitation from national markets’, 3=‘imitation from international markets, 4=‘current products/processes are improved’, 5=‘original products/processes are implemented’. The base of items regarding these capabilities was adapted mainly from OECD Oslo Manual [4]. Each innovation construct was measured by its original measurement items, which were developed accordingly. Note that the innovation measures used in this research were partially new for the literature and required to be validated during the analysis.

The numerical responses to the questions were averaged out to obtain the mean values, which are used to represent the variable associated with the measurement unit.

On the other hand, some of the innovation determinants such as the general firm characteristics and innovation outlay are in a different scale (the answer to these determinants have either nominal values or logical values such as yes or no). Same is true for the marketing and technology strategies.

After the data collection stage, multivariate statistical analyses via SPSS v20 and structural equation modeling approach via AMOS v16 software package were conducted in order to validate the determinants of innovativeness model.

IV. Cluster Analysis

It is of academic and managerial interest to investigate whether manufacturing firms can be grouped into clusters with different emphasis on the five dimensions of innovation. For that purpose a five dimensional cluster analysis is performed to establish taxonomy of the firms based on innovativeness [6].

To accomplish the cluster analysis a hierarchical procedure based on Ward’s agglomerative method is used with squared Euclidean distance measure. As a stopping rule, the elbow criterion is implemented [43]. The cluster analysis results in four distinct clusters. The clusters are categorized through a naming convention that is suitable for each cluster: Leading Innovators (41 firms), Followers (82 firms), Inventors (35 firms), and Laggers (22 firms). Four firms are excluded from the analysis due to incomplete data.

The Leading innovators are the top firms that have a robust reputation in being innovative, and they outperform the other three clusters in all domains of the five definitions of innovation. Followers pursue the innovativeness road that is paved by the Leading innovators and benefit mostly from imitation. They are better off than the Inventors and Laggers in all domains except radical product innovation. Even though the Inventors are ahead of the Followers in terms of radical product innovation, they fall short in other domains and are only better off than the Laggers. The Laggers perform the worst regarding all the innovation dimensions.

Having formed the clusters, a statistical mean comparison is performed for these four groups. Overall mean comparisons, as well as pair-wise mean comparisons are provided in the following sections and the results are tabulated.

V. Research Question And Hypothesis Statement

The research question addressed in this paper is to investigate whether the clusters obtained put different emphasis on different determinants of innovativeness. This research question is formulated as the following hypothesis.

H_0: There is no statistically significant difference among the cluster means of either the drivers of innovativeness or their components.

Each individual hypothesis investigates the possibility of a statistical significance among the clusters, either overall or pair-wise, in relation to the determinant of innovativeness or its component under investigation. These statistical significance results are obtained either with ANOVA or Kruskal-Wallis tests for mean comparisons depending on the results of the normality tests. When during normality test statistical significance ($p<0.05$) is detected, it is concluded that the data is not normally distributed and the non-parametric Kruskal-Wallis test is applied for mean comparison. Otherwise, it is concluded that the data is normally distributed and a one-way ANOVA test is performed.

In any one of the tests, when one of the tests is rejected, then this indicates to a gap between the clusters for the corresponding determinant or its component. This can be considered as an indication for the firms ahead to preserve or even widen this gap and for those lagging to close this gap through policies adopted.

TABLE I. DETERMINANTS OF INNOVATIVENESS MEAN COMPARISON RESULTS

Determinants of Innovativeness	Leading Innovators (Cluster 1)	Followers (Cluster 2)	Inventors (Cluster 3)	Laggers (Cluster 4)	F (or K)
Intellectual Capital					
Cluster Mean	3.868 (2,3,4)	3.436 (1)	3.260 (1)	3.291 (1)	15,407 **p<0.000**
Organizational Structure					
Cluster Mean	3.476	3.322	3.350	3.376	1,654 p<0.179
Organizational Culture					
Cluster Mean	3.673 (4)	3.385	3.300	3.144 (1)	11.739 **p<0.008**
Barriers to Innovation					
Cluster Mean	3.542(3)	3.514(3)	3.049(1,2)	3.373	11.294 **p<0.010**
Collaborations					
Cluster Mean	1.458	1.400	1.392	1.300	5,885 p<0.117

VI. Results For The Determinants Of Innovativeness

The results for the determinants of innovativeness are reported in Table I. Overall mean comparisons, as well as pair-wise mean comparisons are provided. Numbers in parentheses indicate the cluster groups from which this cluster is significantly different at $\alpha=0.05$. It is observed that only the intellectual capital and organizational structure follow a normal distribution with their statistics corresponding to an F-value and all the others to K-values based on ANOVA and Kruskal-Wallis tests, respectively. Bold values indicate statistical significance at $\alpha=0.05$.

There is a statistically significant difference among the four clusters in terms of their innovative capabilities on intellectual capital ($p=0.000$), organizational culture ($p=0.008$), and barriers to innovation ($p=0.010$) dimensions.

On the other hand, hypotheses related to organizational structure and collaborations are not supported. There exists no statistical significance in the organizational structure ($p=0.179$) and collaborations ($p=0.117$) determinants. The mean values for the collaborations are indeed very low indicating to a problem area for the firms in the sample.

The Leading innovators distinguish themselves in the intellectual capital from all other clusters. They also score the highest mean value under the intellectual capital over all determinants of innovativeness. This result is in line with a result reported earlier in [5] that intellectual capital imparts the highest positive impact on innovativeness. The Laggers have the lowest mean score among all four clusters except for the organizational structure determinant. Recall that there is no significant difference among all clusters in the organizational structure. There is a statistically significant difference between the Leading innovators and Laggers in the organizational culture.

The Followers, on the other hand, have the highest mean score second to the Leading innovators except in organizational structure. In the following sections, the same hypothesis test will be implemented at a significance level of $\alpha=0.05$ for the components of the individual determinants excluding the collaboration. The reason for this decision is the very low levels of mean scores achieved across all clusters.

TABLE II. INTELLECTUAL CAPITAL MEAN COMPARISON RESULTS

Intellectual Capital	Leading Innovators (Cluster 1)	Followers (Cluster 2)	Inventors (Cluster 3)	Laggers (Cluster 4)	F (or K)
Human Capital					
Cluster Mean	3.926 (2.3)	3.573 (1)	3.297 (1)	3.527	6.652 **p<0.000**
Social Capital					
Cluster Mean	3.985 (2,3,4)	3.602 (1)	3.377 (1)	3.445 (1)	20.626 **p<0.000**
Organizational Capital					
Cluster Mean	4.042 (2,3,4)	3.317 (1)	3.114 (1)	2.886 (1)	35.133 **p<0.000**

VII. INTELLECTUAL CAPITAL

The three components of intellectual capital; namely, the human capital, social capital, and organizational capital as proposed in the determinants of innovativeness model are tested in terms of their normality for each cluster. It is concluded that the human capital component follows a normal distribution and the social capital and organizational capital components follow non-normal distributions. The one-way ANOVA and Kruskal-Wallis tests are applied accordingly. The cluster means of each resulting category in terms of the four performance factors of the intellectual capital are tabulated in Table II. The one-way ANOVA analysis for the human capital suggests that this component is significantly different among the clusters in terms of their cluster means, while the Kruskal-Wallis analysis for the social capital, and organizational capital yield that these three components exhibit statistical significance depending on their cluster means. A striking observation obtained from Table II is that the mean scores of the Leading innovators exhibit statistical significance in pair-wise cluster mean comparison compared to other three clusters except the human capital, where it does not exhibit a statistical significance compared to the Laggers. The results prove that the crucial nature of the intellectual capital components for sustainable innovativeness is well grasped by the Leading innovators, and they differentiate themselves with the emphasis they place on the intellectual capital.

The Followers is the cluster second in rank with the relatively high intellectual capital scores.

Note that the Inventors fall behind the Leading innovators and Followers in terms of all components of the intellectual capital. Furthermore, although Inventors outclass the Laggers in terms of the organizational capital, they are not able to perform better in terms of the human capital and social capital components. Actually, the Inventor cluster excels particularly in radical product design innovations. The observations cited above can be an indication of isolated innovation efforts rather than pervasive innovation policy on the part of the Innovator firms.

TABLE III. ORGANIZATIONAL STRUCTURE MEAN COMPARISON RESULTS

Organizational Structure	Leading Innovators (Cluster 1)	Followers (Cluster 2)	Inventors (Cluster 3)	Laggers (Cluster 4)	F (or K)
Centralization					
Cluster Mean	2.792	2.616 (4)	2.945	3.166 (2)	3.344 **p<0.021**
Formalization					
Cluster Mean	3.495	3.361	3.233	3.371	0.949 p<0.418
Communication					
Cluster Mean	4.141	3.978	3.872	3.590	0.949 p<0.059

VIII. ORGANIZATIONAL STRUCTURE

As a first step, normality tests are conducted on the components of organizational structure; namely, centralization, formalization, and communication. At a confidence level of α=0.05, centralization and formalization factors are found to have normal distribution and one-way ANOVA tests are applied for mean comparisons. The distribution of communication, on the other hand, revealed to be non-normal. For this reason, non-parametric mean comparison test Kruskal-Wallis is conducted on this component.

The cluster means, the pair-wise comparisons and the related statistics of each resulting cluster in terms of the three performance measures of organizational structure are tabulated in Table III. The statistical tests indicate that there is a statistically significant difference only for centralization among the means of four clusters. Furthermore, if the level of significance is taken, for example, as α=0.10, then we would conclude that there is no statistically significant difference among the means of the clusters for communication.

Centralization involves the following dimensions: Decision making incentives are limited for middle and upper level employees; authority for making decisions on even insignificant issues rests with the senior management; routine decision making and daily tasks require approval from upper level managers; middle and lower level employees are not encouraged to take initiative; middle level managers are not given initiative in the management of processes and tasks; decisions are generally made at the upper levels of the organizational hierarchy.

The Leading innovators outclass all the other clusters in all components of organizational structure, except the centralization component. Follower firms are the least centralized firms slightly better than the Leading innovator firms.

Formalization is represented by the following dimensions: Employees seek assistance for decision making in documents such as organization handbook, procedures and manuals; employees consider their company as a completely institutionalized entity; employees have written and clear job descriptions; employees are not allowed to develop their own rules while conducting their work; employees are monitored constantly whether the initiatives they take violate the corporate rules and procedures; daily applications are expected to be compatible with the standard task procedures.

Communication, on the other hand, has the following dimensions in this study: Employees are asked for their ideas and feedbacks on major changes; employees are informed on major changes; communication channels are open between upper levels of management and the employees; employees are informed on corporate plans; communication channels are open among the employees at the same level of hierarchy.

It is interesting to note that the clusters do not differ among each other considering formalization and they have relatively low mean values between 3.000 and 3.500. The centralization mean values are also relatively low and the scores for communication are relatively high. This picture indeed reminds us of the statement we made earlier that innovation requires low formalization and centralization, but higher levels of internal communication [12].

TABLE IV. ORGANIZATIONAL CULTURE MEAN COMPARISON RESULTS

Organizational Culture	Leading Innovators (Cluster 1)	Followers (Cluster 2)	Inventors (Cluster 3)	Laggers (Cluster 4)	F (or K)
Management Support					
Cluster Mean	3.772 (4)	3.573	3.377	3.154 (1)	13.335 **p<0.004**
Reward System					
Cluster Mean	3.946	3.665	3.331	3.450	8.024 **p<0.046**
Work Discretion					
Cluster Mean	3.468	3.229	3.262	3.000	6.250 p<0.100
Time Availability					
Cluster Mean	3.504	3.069	3.228	2.969	7.473 p<0.058

IX. ORGANIZATIONAL CULTURE

Tests conducted for checking normality for all components of the organizational culture; namely, management support, reward system, work discretion, and time availability result in the conclusion that all components follow non-normal distributions. For this reason, non-parametric mean comparison test Kruskal-Wallis is conducted on these four components.

The cluster means, overall and pair-wise comparisons for each cluster in terms of the four components of organizational culture are tabulated in Table IV. The findings suggest that there is a statistically significant difference among cluster means for management support (p=0.004) and reward system components with (p=0.046); while there exist no such statistically significant result among clusters for work discretion (p=0.058) and time availability components (p=0.100). On a pair-wise comparison, a statistical significance is detected between cluster means of the Leading innovators and the Laggers for the management support component.

The management support component contains the following dimensions considered in this study: The development of new and innovative ideas are encouraged; in my organization, developing one's own ideas is encouraged for the improvement of the corporation; senior managers encourage innovators to bend rules and rigid procedures in order to keep promising ideas on track; every employee is willing to develop new ideas and projects; it is encouraged that employees from different department come together to develop new project ideas; upper management is aware and very receptive to the employees' ideas and suggestions; money is often available to get new project ideas off the ground; employees can easily reach necessary information to do their job; there are several options within the organization for individuals to get financial support to actualize their innovative projects; individual risk takers are often recognized for their willingness to champion new projects, whether eventually successful or not; the term risk taker is considered a positive attribute for people in my work area.

For the reward component the dimensions are formulated as follows: Employees with innovative and successful projects will be highly rewarded; the rewards that employees received or will receive are dependent on their work on the job;

employees from every level will be rewarded, if they innovate; employees will be appreciated by their managers if they perform very well; managers increases employee's job responsibilities, if they perform well.

Work discretion, on the other hand, consists of the following dimensions: The employee has the freedom to implement different work methods for doing assigned major and routine tasks from day to day; it is basically the employee's responsibility to decide how my job gets done; the organization provides freedom to the employees to use their own judgment and methods; the employees have the freedom to decide how to execute their job.

Note that, if the level of significance is taken as α=0.10, then for the time availability component the difference among the cluster means will turn out to be statistically significant. For the time availability the following dimensions are considered in this study: The employees always feel to have plenty of time to get everything done; the employees have enough time to spend for developing new ideas; the employees have just the right amount of time and work load to do everything well.

The Leading innovators appear to be superior to all the other clusters in all components of the organizational culture. As a result of the pair-wise statistical significance investigation, the Leading innovators outperform the Laggers in terms of management support component, suggesting that these firms are specifically better at supporting their employees' innovative endeavors compared to the Laggers. The Followers are behind the Leading innovators in the management support and reward system components, while they are performing slightly worse in work discretion and time availability compared to the Inventors. As expected, Laggers have the lowest scores in all components of organizational culture, except the reward system. The Laggers cluster lags behind all other clusters, but are slightly better at incentivizing the innovative activities compared to the Inventors.

TABLE V. BARRIERS TO INNOVATION MEAN COMPARISON RESULTS

Barriers to Innovation	Leading Innovators (Cluster 1)	Followers (Cluster 2)	Inventors (Cluster 3)	Laggers (Cluster 4)	F (or K)
Internal Resistance					
Cluster Mean	3.802	3.714	3.500	3.375	6.269 p<0.099
Internal Deficiencies					
Cluster Mean	3.358	3.339 (3)	2.742 (2)	3.370	9.831 **p<0.020**
Internal Limitations					
Cluster Mean	3.486 (3)	3.214	2.870 (1)	3.028	3.580 **p<0.015**
External Difficulties					
Cluster Mean	3.612	3.851	3.507	3.818	4.692 p<0.196
External Limitations					
Cluster Mean	3.445	3.454	3.073	3.215	4.525 p<0.210

X. BARRIERS TO INNOVATION

As a result of the normality tests; internal resistance, internal deficiencies, external difficulties and external limitations components are detected to have non-normal distribution and non-parametric one-way Kruskal-Wallis tests are applied for mean comparisons. On the other hand, the distribution for the internal limitations component revealed to be normally distributed. For this reason, parametric one-way mean comparison ANOVA test is conducted on this component.

The cluster means of each resulting cluster in terms of the five performance components of barriers to innovation are tabulated in Table V, both overall and pair-wise. Statistical significance exists in internal deficiencies (p=0.020) and internal limitations (p=0.015). There is no statistical significance detected in internal resistance (p=0.099), external difficulties (p=0.196) and external limitations (p=0.210) as a result of the non-parametric Kruskal-Wallis test at this confidence interval.

Note that for internal resistance, the difference of the means over the clusters would be significant for α=0.10. The component designated as internal resistance is designed to include the following dimensions: Corporate climate is not suitable for innovation; the company does not value continuous improvement; resistance to innovativeness in the workplace; upper level managers are faulty/slow in their approval process; lack of clarity in the goals of innovation projects; lack of supervision on innovation processes; lack of strategy based on innovation processes; excessive monotonous and routine workload.

The results in Table V indicate that the Leading innovators is the cluster, which has been more successful in overcoming the internal resistance and the Laggers the least successful.

The dimensions associated with internal deficiencies are stated as follows: Insufficient technical experience; insufficient technical knowledge; insufficient number of qualified personnel; difficulty in finding/hiring qualified personnel; lack of qualified R&D manager.

For internal limitations, on the other hand, the dimensions considered are: High costs of innovation; insufficient financial resources; high risks associated with innovation; time constraints for intrafirm technological development; lack of organization for technology transfer.

When investigated pair-wise, the Followers and Inventors statistically differ in their means in terms of internal deficiencies component, whereas the Leading innovators and Inventors significantly differ in the internal limitations. The Inventors indeed seem to be the cluster suffering most under the barriers to innovation.

Considering the scores, it appears that the firms in all clusters seem to have difficulties to overcome the barriers related to both internal deficiencies and limitations. Hence, the firms need to put more emphasis on developing policies and action plans to reduce the impact of these two components.

When considering external difficulties and limitations there is no difference among the clusters for both components. The mean scores of the clusters for external difficulties are the highest among the components of barriers to innovation together with the internal resistance meaning that they consider the barriers associated a relatively less threat to their innovativeness. The dimensions of external limitations are specified as: Difficulty in obtaining the required material, parts, or equipment; deficiency in acquiring technological services obtained from third party resources; loopholes in the protection of intellectual property rights; difficulty in accessing technological information resources; difficulty in customer's adaptation to new product.

XI. Conclusion

In this study, we have tested the hypothesis that there is no statistically significant difference among the cluster means of either the drivers of innovativeness or their components. For that purpose we employ data gathered in earlier study some results of which have been reported in [5], [6], and [31].

At the level of determinants of innovativeness, it is shown that intellectual capital, organizational culture, and barriers to innovation explain the difference between the mean levels of innovativeness of different clusters at a significance level of $\alpha=0.05$.

The same hypothesis has been applied to the individual components of each determinant of innovativeness again at a significance level of $\alpha=0.05$. Although organizational culture has not been found to be significant, still its components have been tested for significance. This has not been the case for collaboration due to the very low levels of mean scores across all clusters.

Some conclusions with managerial implications will be shared here. As stated above one conclusion is that all firms have to put emphasis on improving communication in all components of communication; R&D, vertical, and operational collaborations. The mean scores reported are indeed the lowest across all determinants and their components.

Among the determinants intellectual capital is the most influential one in differentiating among the clusters. This indicates to the importance of intellectual capital for innovativeness in a manufacturing firm.

This is indeed in line with the conclusions drawn from the SME analysis of the database [5]. The same conclusion prevails once we investigate its components human, social, and organizational capital.

Organizational structure is determined to be the second most influential determinant for distinguishing between the clusters. It appears that the other clusters, particularly the Laggers, have to improve themselves in the various components of organizational structure.

A good policy concerning organizational structure with its components as centralization, formalization, and communication, the management should seek relatively low levels of centralization and formalization and relatively high levels of communication. This appears to be the current situation among the clusters in this study, which needs to be preserved.

A distinguishing characteristic among the clusters is the management support. This is expected in the sense that the implementation of an innovation strategy in a firm is a change process and requires management support to be successful. Top management needs to make it clear to the employees at all levels of the firm that it supports the change process fully.

Another distinguishing characteristic is the reward component. It appears clearly that a just and fair reward policy open to all levels of employees is a powerful tool for motivating the personnel in their innovation efforts.

A further managerial implication is that time availability is needed for the employees to develop a deep understanding for the work they do and its implications. They need time and opportunity to reflect on their work so that they come up with innovative ideas. Obviously these ideas cannot be transformed into concrete results without management support.

The dimensions of internal resistance employed in this study can be considered as combination of the resistance to change inherent in the employees and the innovation climate in the firm. To overcome the resistance to change smooth deployment is needed of the innovation strategy and the related action plans to be implemented to the employees at all levels. The building of an innovation climate in the firm is again expected from the management.

Sufficient innovation outlay is needed together with an environment not penalizing risk taking.

To sustain innovation in a firm access to good human resource should be secured particularly to people with good technical knowledge and experience. Furthermore, managing the two-way flow of technology and innovation in and out of the firm requires an effective gate keeping mechanism – an indispensable mechanism in an innovative firm.

REFERENCES

[1] J.A. Schumpeter, The Theory of Economic Development. An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle. Cambridge, Harvard University Press, 1934.

[2] P.F. Drucker, Innovation and Entrepreneurship. Oxford, Butterworth-Heinemann, 1985.

[3] European Commission Communication, Living and working in the information society: People first. COM, (Green Paper) 389, July 1996.

[4] OECD, Oslo Manual: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data, OECD Publications, Paris, 2005.

[5] G. Ulusoy, Kilic, K., Günday, G. and Alpkan, L., A determinants of innovativeness model for manufacturing firms. International Journal of Innovation and Regional Development, vol. 6, No. 2, pp. 125-158, 2015.

[6] K. Kilic, Ulusoy, G., Günday, G. and Alpkan, L., Innovativeness, operations priorities and corporate performance: An analysis based on a taxonomy of innovativeness, Journal of Engineering and Technology Management, vol. 35, pp. 115-133, 2015.

[7] M. Zerenler, Hasiloglu, S.B., and Sezgin, M., Intellectual capital and innovation performance: empirical evidence in the Turkish automotive supplier, Journal of Technology Management and Innovation vol. 3, No.4, pp. 31-40, 2008.

[8] L.A., Joia, Measuring intangible corporate assets linking business strategy wth intellectual capital, Journal of Intellectual Capital, vol. 1, No. 1, pp. 68-84, 2000.

[9] M. Dakhli and De Clercq, D., Human capital, social capital, and innovation: A multicountry study. Entrepreneurship & Regional Development, vol. 16, pp. 107–128, 2004.

[10] J., Nahapiet and Ghoshal, S., Social capital, intellectual capital, and the organizational advantage. Academy of Management Review, vol. 23, pp. 242–266, 1998.

[11] M.A. Youndt, Subramaniam, M. and Snell, S.A.,Intellectual capital profiles: an examination of investment and return, Journal of Management Studies vol. 41 No. 2, pp. 335–361, 2004.

[12] L. Donaldson, The Contingency Theory of Organizations, Sage Publications, Los Angeles, 2001.

[13] T. Burns and Stalker, G.M., The Management of Innovation. Tavistock Publications, London, 1961.

[14] C.S., Koberg, Uhlenbruck, N., and Sarason, Y., Facilitators of organizational inovation: the role of lifecycle stage. Journal of Business Venturing; vol. 11, pp. 133–149, 1996.

[15] S. Khazanchi, Lewis, M. W. and Boyer, K. K., Innovation-supportive culture: the impact of organizational values on process innovation. Journal of Operations Management, vol. 25, pp. 871–884, 2007.

[16] D. F. Kuratko, Montagno, R. V., and Hornsby, J.S., Developing an intrapreneurial assessment instrument for an effective corporate entrepreneurship. Strategic Management Journal 1990; 11: (5), 49-58.

[17] J.S. Hornsby, Kuratko, D.F., and Zahra, S.A., Middle managers' perception of the internal environment for corporate entrepreneurship: Assessing a measurement scale. Journal of Business Venturing, 2002; 17: 253–273.

[18] R.M. Kanter, When a thousand flowers bloom: Structural, collective, and social conditions for innovation in organization. In Paul S. Myers (ed.), Knowledge Management and Organizational Design, pp.93-131, Butterworth-Heinemann, Boston, 1996.

[19] F. Damanpour, Organizational innovation: A meta-analysis of effects of determinants and moderators. Academy of Management Journal, 1991; 14 (4): 555-590.

[20] J.S., Hornsby, Naffziger, D.W., Kuratko, D.F., and Montagno, R.V., An intractive model of the corporate entrepreneurship process. Entrepreneurship Theory Practice, vol. 17, No. 2, pp. 29-37, 1993.

[21] J. Sundbo, Empowerment of employees in small and medium-sized service firms. Employee Relations, vol. 21, No.2, pp. 105-127, 1992.

[22] L. Alpkan, Bulut, C., Gunday, G, Ulusoy, G., and Kilic, K., Organizational support for intrapreneurship and its interaction with human capital to enhance innovative performance, Management Decision, vol. 48, No. 5, pp. 732-755, 2010.

[23] H.H. Stevenson, and Jarillo, C.J., A paradigm of entrepreneurship: Entrepreneurial management Strategic Management Journal, vol. 11, No. 5, pp. 17-27, 1990.

[24] A.S. Fry, The post it note: An intrapreneurial success. SAM Advanced Management Journal, vol. 52, No. 3, pp. 4-9, 1987.

[25] G. Pinchot, Intrapreneuring: Why You Don't Have to Leave the Corporation to Become an Entrepreneur. Harper and Row Publishers, New York, NY, 1985.

[26] J.V.D. Ende, Wijnberg, N., Vogels, R., and Kerstens, M., Organizing innovative projects to interact with market dynamics: A coevolutionary approach. European Management Journal, vol. 21, No. 3, pp. 273-284, 2003.

[27] L. Alpkan, Yilmaz, C., and Kaya, N., Market orientation and planning flexibility in SMEs: performance implications and an empirical investigation. International Small Business Journal, vol. 25, No.2, pp. 152-172, 2007.

[28] I. Gurkov, Innovations in Russian industries: conditions for implementation and impact on competitiveness. Journal for East European Management Studies, vol. 10, No. 3, pp.218-246, 2005.

[29] E.W. Morrison, Robinson, S.L., When employees feel betrayed: A model of how psychological contract violation develops. Academy of Management Review, vol. 22, No. 1, pp. 226-25, 1997.

[30] G.N. Chandler, Keller, C, Lyon, D.W., Unraveling the determinants and consequences of an innovation-supportive organizational culture. Entrepreneurship: Theory and Practice, vol. 25, No. 1, pp. 59-76, 2000.

[31] G. Günday, Ulusoy, G., Kilic, K. and Alpkan, L., Effects of innovation types on firm performance. International Journal of Production Economics, 133, pp. 662-676, 2011.

[32] K.K. Boyer, and Lewis, M.W., Competitive priorities: investigating the need for trade-offs in operations strategy. Journal of Production and Operations Management, vol. 11, pp. 9–20, 2002.

[33] L. Alpkan, Ceylan, A. and Aytekin, M., Performance impacts of operations strategies: a study on Turkish manufacturing firms. International Journal of Agile Manufacturing, vol. 6, pp. 57-65, 2003.

[34] M.A. Noble, Manufacturing competitive priorities and productivity: an empirical study. International Journal of Operations & Production Management, vol. 17, pp. 85-99, 1997.

[35] P.T. Ward, McCrery, J.K., Ritzman, L.P. and Sharma, D., Competitive priorities in operations management. Decision Sciences, vol. 29, pp. 1035-1046, 1998.

[36] S.K. Vickery, Droge, C. and Markland, R.E., Production competence and business strategy: do they affect business performance?. Decision Science, vol. 24, pp. 435-455, 1993.

[37] R. Kathuria, Competitive priorities and managerial performance: a taxonomy of small manufacturers. Journal of Operations Management, vol. 18, pp. 627-641, 2000.

[38] E.M. Olson, Slater, S.F. and Hult, G.T.M., The performance implications of fit among business strategy, marketing organization structure, and strategic behaviour. Journal of Marketing, vol. 69, No. 3, pp. 49-65, 2005.

[39] M. Subramaniam, and Youndt, M.A. The influence of intellectual capital on the types of innovative capabilities. Academy of Management Journal, vol. 48, pp. 450-463, 2005.

[40] O. C. Walker, and Robert W. R., Marketing's role in the implementation of business strategies: a critical review and conceptual framework. Journal of Marketing, vol. 51 No. 3, pp. 15–33, 1987.

[41] B.J. Jaworski, and Kohli A.K., Market orientation: antecedents and consequences. Journal of Marketing, vol. 57, No. 3, pp. 53-70, 1993.

[42] A. Menon, Bharadwaj, S., Adidam, P. and Edison S,, Antecedents and consequences of marketing strategy making. Journal of Marketing, vol. 63, No. 2, pp. 18–40, 1999.

[43] J.F. Hair, Anderson, R.E., Tatham, R.L. and Black, W.C., Multivariate Data Analysis: With Readings. Pearson Prentice Hall, 6th edition, New Jersey, 2006.

BIOGRAPHY

Mete Sevinç is a PhD candidate in the School of Industrial Engineering at the Eindhoven University of Technology, Netherlands. He received a BSc in Manufacturing Systems Engineering (2012) and a MSc in Industrial Engineering (2014) at Sabanci University, Istanbul. He completed his MSc thesis about an analysis on Innovation Taxonomy and Data Envelopment Analysis. He has previously worked in Turkey, and taken part in research projects in Sweden and Singapore. Currently, he conducts research on Supply Chain Control and Compliance through Bayesian Network Modeling. His research interests include Risk Assessment, Bayesian Network Modeling, Supply Chain Management, Datamining, Statistics and Information Visualization.

Gündüz Ulusoy received his BSc in mechanical engineering from Robert College, Istanbul (1970); MSc in mechanical engineering from University of Rochester (1972) and PhD in OR from Virginia Tech (1975). He served in the IE Department of Boğaziçi University in Istanbul as a faculty member (1976-1999) and as Head of Department (1985-1993) and also as Vice President (1992-1994). In 1983, he worked as a postdoc in the OR Department at Lancaster University. He spent a year in industry on-leave from Boğaziçi University (1984-1985). He was a member of the Executive Board of the Turkish Scientific and Technical Research Council TÜBİTAK (1993-1997) and Chairman of the Executive Board of the Marmara Research Center (1995-1997). He served on the Executive Board of the Turkish Quality Association (1998-2002) and chaired its Quality Award Committee (1998-2002). In 1999 he joined Sabancı University and established the Manufacturing Systems Engineering Program there. In 2003 he founded the TUSIAD-Sabancı University Competitiveness Forum and served as its Director (2003-2008). He was an Associate Editor of EJOR and IAOR, Chief Editor of the Turkish Journal of Operational Research and Guest Editor for several academic journals. His research areas include innovation and manufacturing strategies, evolutionary algorithms, and project and machine scheduling.