Innovativeness, operations priorities and corporate performance: An analysis based on a taxonomy of innovativeness

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This paper is accepted by the Journal of Engineering and Technology Management.

Please cite this article in press as: Kilic, K., et al., Innovativeness, operations priorities and corporate performance: An analysis based on a taxonomy of innovativeness. J. Eng. Technol. Manage. (2014), http://dx.doi.org/10.1016/j.jengtecman.2014.09.001

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ABSTRACT

The paper analyzes the relations among the manufacturing firm's innovativeness, operations priorities, and corporate performance. As opposed to common practice in the literature in which these relations are analyzed on a dichotomous (High vs. Low) classification of innovativeness mostly times based on product and/or process innovations, taxonomy based approach is used here. Our findings demonstrate that leading innovators simultaneously compete effectively on multiple operations priorities and obtain the best corporate performance. This research also demonstrates that incorporating shades of grey via the more elaborate taxonomy based approach brings to the fore hidden relations that were otherwise buried in the data.

Keywords: Innovation Management, Operations Priorities, Corporate Performance, Taxonomy

1. INTRODUCTION

In an early literature review on innovativeness, Midgley and Dowling (1978) posits that for the majority of existing research at the time, innovativeness is conceptualized as the degree to which an individual adopts an innovation relatively earlier than others. This temporal conception of innovativeness later changed and other conceptualizations became more popular. For example, Hurley and Hult (1998) define innovativeness as the notion of openness to new ideas as an aspect of a firm culture and propose an input based operationalization of innovativeness, i.e., innovativeness is measured based on its antecedents. In contrast, Damanpour and Evan (1984) assert that an innovation is realized after implementation of a new idea. In line with this assertion, Damanpour (1991) defines innovativeness as the rate of adoption of innovations and indicates that it is operationalized in many studies as the number of innovations adopted within a given period. This conceptualization of innovativeness has led to numerous studies that have an output based measure of innovativeness (Ellonen et al. 2008; Tellis et al., 2009; Man 2009), i.e., innovativeness is measured based on realized innovations.

Even though earlier researchers in innovation management literature have mostly focused on two types of innovations, namely product and process innovations, recently other types of innovations began to receive more attention. The OECD Oslo Manual (2005) defines four different innovation types: product, process, marketing, and organizational innovations. Furthermore, the product innovation is considered in two components: incremental and radical product innovations. This recent multi dimensional approach to innovation has enriched discussions and enhanced its role particularly in corporate performance and strategic management.

On the other hand, there has been a broad agreement on the composition of the operations priorities, namely, cost, quality, flexibility and delivery/dependability (Hayes and Wheelwright, 1984; Voss, 1995; Boyer and Lewis, 2002). Even though Leong et al. (1990) introduced innovation as the fifth operations priority, other than rare examples such as Lau Antonio et al. (200) it is yet to receive the same level of attention by the research community as have the former four dimensions (Nair and Boulton, 2008; Avella et al., 2011). Therefore, in this research we adopt the more general approach which positions innovativeness out of the operations priorities set yet nevertheless investigates their interactions.

Business researchers acknowledge both innovativeness and operations priorities among the most attractive subject areas of corporate performance and strategic management (Damanpour, 1987; Hayes et al., 1988; Boyer and Lewis, 2002; Sum et al., 2004). Some researchers have focused on the role of innovativeness on firm performance (e.g., Zahra and Sidhartha, 1993; Damanpour et al., 1989; Gunday et al., 2008; Man, 2009; Bolívar-Ramos, 2012). On the other hand, another stream of research investigates the relationship between operations priorities and innovativeness (Utterback and Abernathy, 1975; Baldwin and Johnson, 1996; Alegre-Vidal et al., 2004). Nevertheless, the relationship between operations priorities and firm performance has been the most widely studied; foundations have been laid by seminal works such as Skinner (1969, 1978), Hayes and Wheelwright (1984) and Miller and Roth (1994).

The literature regarding the first two relationships (namely, (1) innovativeness and performance (2) innovativeness and operations priorities) utilizes the traditional dichotomous approach (high innovativeness / low innovativeness) where innovativeness is operationalized with a single dimensional measure in their analysis. However, as discussed earlier, the multidimensional nature of innovativeness makes treating it with a single dimensional measure actually problematic. For example, there can be firms that are highly innovative in terms of various dimensions, say, incremental product innovations and process innovations but nonetheless perform badly in other types of innovations. A reductionist approach would lead to categorize such firms (which can be summarized as *average innovative*) together with firms that actually perform on average in all innovation types. Therefore, a taxonomical approach based on multi dimensional clustering has the potential to not only better represent reality than do the more traditional single dimensional and dichotomous approaches but also reveal otherwise hidden relations. .

As a matter of fact, such studies which are based on taxonomy of operations priorities do exist and focus on the relationship between operations priorities and firm performance (Miller and Roth, 1994; Kathuria, 2000; Sum et al., 2004: Prajogo et al., 2014). However, even though some taxonomies of innovativeness are available in the literature (Avermaeta et al., 2004; Lehtoranta, 2005; Balcerowicz et al., 2009), they are not used to determine the relationship between innovativeness and operations priorities or how the firms perform in different innovativeness clusters. Furthermore, the taxonomies of innovativeness available in the literature are based on only product and process innovations, and only one of them (namely, Balcerowicz et al., 2009) utilizes formal cluster analysis. Hence, there is actually a lack of taxonomy of innovativeness based on formal cluster analysis of all types of innovations.

In this research, we will first of all address this gap and develop taxonomy of innovativeness. Later, this taxonomy will be used in order to determine how firms in different innovativeness clusters rank their operations priorities and how they perform in terms production, marketing and financial performance. Such an analysis based on taxonomy would be invaluable particularly for top management while developing strategies regarding to their innovativeness. Note that taxonomy based analysis of the relationship between innovativeness and operations priorities also contributes to the ongoing debate between the two competing models proposed in order to understand the dynamics of operations priorities, namely, Skinner's (1969, 1974) trade-off (*focused factory*) model, the sand cone (*cumulative*) model (Nakane, 1986; Ferdows and De Meyer, 1990) to a degree.

The paper has six sections. The review of the relevant literature in detail and the research questions are presented next. The third section describes the data collection phase and the measurement of the variables. Analyses are presented in section four. The results and the discussions are introduced in the fifth section. The paper concludes with final remarks in section six.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

In order to enhance the understanding and communication of various concepts, the determination of typologies and taxonomies is an integral approach in strategy research (Martin-Pena and Garrido, 2000). Unlike the typologies, which refer to the ideal types, the taxonomies are based on empirical classification of the companies, which are mutually exclusive, and collectively exhaustive (Bozarth and McDermott, 1998). For example, Hill's (1994) five process types, i.e., project, job shop, batch, line and continuous process is a notable example of typologies. Typologies refer to a classification system from a theoretical perspective, i.e., based on a conceptual framework developed a priori. On the other hand, taxonomies differ from typologies since they lack the a priori theoretical framework, are based on a posteriori approach, and emerge from empirical analysis (Martin-Pena and Garrido, 2000).

Various taxonomies in the context of operations priorities are available. An extensive literature review is presented by Martin-Pena and Garrido (2000). One example of taxonomy is proposed by Miller and Roth (1994), which is based on operations priorities and yields three strategy types: Caretakers, Innovators and Marketers. A different taxonomy of operations priorities is proposed by Sum et al. (2004) and according to their taxonomy, companies are classified into three groups: All-Rounders, Efficient Innovators and Differentiators. A third taxonomy based on the operations priorities is further proposed by Kathuria (2000), which classifies the companies into four groups, namely, Starters, Efficient Conformers, Speedy Conformers, and Do Alls.

The taxonomy of innovativeness by clustering firms according to their innovativeness pertaining to various innovation types (i.e., product, process, marketing and organizational) is non-existent to date. Avermaeta et al. (2004) are among the first researchers who propose a taxonomy of innovativeness based on an empirical analysis of 177 small food firms from the UK, Belgium and the Republic of Ireland. Rather than a formal cluster analysis, the authors set specifications and group the firms regarding these conditions. They conclude that firms can be grouped into four homogenous categories such as Non Innovators, Traditional, Followers, and Leaders. Note that preset specifications focus only on the product and process innovations. Lehtoranta (2005) utilizes Finnish VTT Sfinno Database in order to determine what type of SMEs are innovative. In the analysis, the taxonomy of the innovativeness based on innovation intensity was proposed, which suggests three groups of companies, namely, intensive innovators, persistent innovators and innovators with one innovation. Again these categories are formed based on preset specifications (e.g., firms that have commercialized five or more innovations between 1980 and 1999 are labeled as intensive innovators, etc.) rather than formal cluster analysis. Note that the focus of this study is also limited to product and process innovations.

A taxonomy based on formal cluster analysis is developed by Balcerowicz et al., (2009). In their analysis, data collected from 58 companies from various industries in the Czech Republic, Hungary, Poland and Spain were utilized. Two different taxonomies, one regarding Low and Medium Technology (LMT) firms and the other regarding High Technology (HT) firms, are provided. The LMT firms are grouped into six groups based on linkages and beneficial cooperation, low profile, short term competitiveness strategy, hunters for product innovation, and high profile. Similarly the HT firms are grouped into four, namely, benefiting from cooperation, high profile, hunters for product innovation, and in-house backed by cooperation. Note that the current research limits its focus only to product innovations.

. The literature hints usage of taxonomies in the context of innovation management research. However, the existing taxonomies are based on product and/or process innovations and only one of them is based on formal cluster analysis. Nevertheless, a taxonomy of innovativeness that incorporates all types of innovations and utilizes formal cluster analysis would provide an invaluable framework for the researchers and decision makers. Therefore, a taxonomy established on the firm level innovativeness pertaining to various innovation types by utilization of cluster analysis is required,; thus, leading to the first research objective of the paper.

Another research challenge in the scope of the paper is the linkage between operations priorities and innovation. Utterback and Abernathy (1975) are among the first to study the relationship between product and process innovations and operations priorities. The researchers conclude that those firms that undertake more product innovations should focus on quality and flexibility; however, those that undertake more process innovations mostly focus on cost. Baldwin and Johnson (1996) investigate the differences in the strategies of more and less innovative companies in a Canada based on the survey conducted by Statistics Canada. The analysis reveals that more innovative companies focus on delivery, flexibility and quality significantly more than do less innovative companies. In this research, innovativeness was measured based on various antecedents of innovations (i.e., competitive orientation, innovation strategy, investment devoted to R&D, etc.). Alegre-Vidal et al. (2004) study the link between product innovation and operations priorities based on an empirical survey conducted among Spanish ceramic tile manufacturers. There firms are classified as more innovative or less innovative firms based on the number of new product developments. Somewhat parallel to the existing literature, their results indicate that more innovative firms emphasize flexibility and quality significantly to a greater extent than do less innovative firms.

Note that the above mentioned research exhibits significant gaps in the literature. First of all, their attention is only limited to product and process innovations (rather than other types of innovations, i.e., organizational and marketing). Furthermore, this research uses the dichotomous classification of innovativeness (such as high innovativeness and low innovativeness) which is operationalized with a single dimensional measure of innovativeness as opposed to a taxonomy based on natural groupings (i.e., multidimensional clusters). In order to address this gap in the literature, the first research hypothesis is stated as follows:

H1: Different innovation clusters put different emphasis on different operations priorities (cost efficiency, flexibility, delivery and quality).

One of the active research areas in operations strategy literature is the selection and/or combination of the most appropriate operations priorities for better performance. Although the trade-off model (Skinner, 1969; Skinner, 1974) and the sand-cone model (Nakane, 1986; Ferdows and De Meyer, 1990) are the two competing proposals that suggest how firms should align their operations priorities with their industrial ecosystems, some researchers perceive the two models as complementary rather than competing and suggest an integrative model (Schroeder et al., 2011; Avella et al., 2011). The sand-cone model asserts that as opposed to the trade-off model, which assumes that there is incompatibility among the priorities, the priorities are accumulative in nature; hence, it is possible to build up a balanced strategy, i.e., the multiple concentration approach is viable.

The ambidexterity literature also supports the multiple concentration approach. According to this literature, the combination or reconciliation of seemingly contradictory -but in the long term in essence complementary- alternatives contribute to firm performance better than does selecting only one alternative (e.g., Duncan, 1976; Tushman and O'Reilly, 1996; Mengüç and Auh, 2008). However, in most of the empirical studies, if not all, this linkage is tested via relational analyses (i.e., regression, path models, etc.) but not via direct comparison of firm clusters according to their strategic choices.

Our analysis on the first research hypothesis will contribute to this ongoing debate in the operations strategy literature. As a result of the analysis, we can observe: if the innovativeness clusters adopt a multiple concentration approach; if the innovation clusters concentrate on only some of the operations priorities; or, lastly, if both are possible, i.e., an integrative model in which some firms adopt multiple concentration and some others focus only on some of the priorities. Note that because the data set utilized in this paper is cross sectional, our conclusions will thus be limited. For a more conclusive result, particularly for the validation of the sand-cone model which implies an ordering among the operations priorities, a longitudinal study might be more appropriate.

Various taxonomies of the organizations based on operations priorities suggest that many firms seem to simultaneously focus on multiple operations priorities (Miller and Roth, 1994; Kathuria, 2000; Avella et al., 2011), a finding/an approach which more fits the sand-cone model. The results of such taxonomies raise the question of how these companies focusing on multiple priorities simultaneously perform when compared with others that don't. Kathuria (2000) demonstrates that different groups of companies perform better on certain performance measures that are consistent with their focus. The results suggest that those companies, which simultaneously emphasize all four operations priorities, perform well. Miller and Roth (1994) report performance differences among different organizations with different operations priorities. Based on an empirical study, Noble (1997) demonstrates that manufacturing strategies of high-performing firms are unlike low-performing firms. Their findings support that high performing firms are more probable to concurrently concentrate on multiple capabilities and are more likely to possess clearly defined competitive strategies.

The above mentioned literature suggests an indirect linkage between innovativeness and corporate performance via operations priorities. Several researchers have attempted to explicitly represent the positive impact of innovations on corporate performance. Damanpour et al. (1989) introduces a typology that consists of four different types of companies based on their adoption of technical and administrative innovations (i.e. high technical and high administrative, low technical and high administrative, etc.). Based on this typology, they demonstrate that high levels of adoption of both administrative and technical innovations lead to higher organizational performance. Zahra and Sidhartha (1993) also conclude that innovation strategy is an important major predictor of financial performance. Gunday et al. (2008, 2011) report that innovative firms are rewarded by higher corporate performance including financial, production, and marketing performance(s). Even though the majority of research hints that more innovative firms have better performance, there is also contradictory evidence in the literature. For example, based on an empirical analysis of SMEs, Man (2009) concludes that there is no evidence to support that more innovative firms have better performance. Note that there is virtually no research that investigates firm performance based on taxonomy of companies with respect to their innovativeness. On the other hand, one reasons for the contradictory results in the literature might stem from the dichotomous classification of companies based on their innovativeness. This gap in the literature leads us to the following research hypothesis:

H2: Different innovation clusters demonstrate different corporate performance levels (financial, production, market).

3. METHODOLOGY

3.1. Data Collection

A questionnaire consisting of 311 individual questions was developed for the upper managers of manufacturing companies. The questionnaire is designed to assess a firm's business strategy, 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 pre-tested through 10 pilot interviews to ensure appropriate wording, format, and sequencing of questions. .

Data was collected over a 7-month period using a self-administered questionnaire distributed to firms' upper level managers operating in six different manufacturing sectors (textile, chemical, metal products, machinery, domestic appliances, and automotive industries) in the Northern Marmara region in Turkey. Because of the diversity of the organizational structures, where corporate strategies are developed, manufacturing was selected as the unit of analysis.

A total of 1674 firms were selected randomly, from the database(s) of the Union of Chambers and Commodity Exchange (TOBB) and Istanbul, Kocaeli, Tekirdag, Cerkezkoy and Sakarya Industry Chambers, as well as member lists of various Industry Parks in Northern Marmara region. The number of firms selected from each sector and province covered in the study represents the number of firms in that sector and province. Randomly selected face-to-face structured interviews with the same questionnaire were concurrently arranged with the mail application. The dispersion of the firms to the sectors and firm characteristics such as firm size were considered in order to obtain a true randomized and representative sample when arranging for interview appointments. From 120 invitations extended, a total of 101 interviews were performed. Together with the responses from the mail survey, we obtained 184 usable questionnaires resulting in a response rate of 11%. All respondents completing the questionnaire were from top or middle management (CEO/Owner (7%), General Director (24%), Assistant General Director (5%), Plant Director (15%), Production Director (22%), R&D Director (12%), Finance Director (8%), Quality Director (4%), Sales Director (2%) and Marketing Director (1%)).

Implementing a series of comparative tests regarding firm distributions according to sectors ascertains the degree to which the sample represents the population. 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.

{ Insert Figure 1 Around Here}

The data is also controlled with *t*-test procedure for *non-respondent bias;* there is no significant difference ($p \leq 0.05$) between the interview and mailing data sets responses both in terms of the questionnaire items and constructs, i.e., innovation and firm performance variables as well as in terms of firm characteristics such as firm size, firm age, total sales, ownership status and the existence of some level of foreign investment in the company. Note that this result also suggests the absence of a mixed mode effect due to the multiple mode approach undertaken during the data collection stage and enabled us to safely merge the data from face-to-face interviews and mailing application (De Leeuw, E. D., 2005).

The Common Method Variance (CMV) bias was also addressed. Procedural precautions such as using established scales, some methodological separation of measurement, counterbalancing question order, improving scale items and protecting anonymity were taken prior to the research. Furthermore, Harman's single factor test (Harman, 1967) is also applied as suggested in the literature (Kathuria, 2000; Podsakoff et al., 2003; Zu et al., 2010; Wei et al., 2014). In the single factor test, all factors in a study are subject to exploratory factor analysis (EFA). Then, CMV is assumed to exist if (1) a single factor emerges from unrotated factor solutions, or (2) a first factor explains the majority of the variance in the variables (Podsakoff and Organ, 1986, p.536). Neither condition is observed as the result of the EFA; hence, a strong evidence against CMV bias in the results is revealed.

The resulting sample profile is displayed in ***Figure 1***. 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 firm age by the year a firm started production (earlier than 1975: old; between 1975 and 1992: moderate; later than 1992: young).

After the data collection stage, multivariate statistical analyses via SPSS v13 software package were conducted in order to validate the research framework. Occasional missing data were randomly distributed (MAR) on items and handled by list wise deletion.

3.2. Measurement of Variables

The questionnaire form is prepared by considering recent questionnaire forms used in similar studies and commonly accepted measures met in the current literature.

The questions about innovativeness are asked by employing a 5-point Likert scale. The respondents are asked to indicate "to what extent the innovations implemented in their organization in the last three years related to the following kinds of activities" 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'. Such subjective measures possibly bring in respondent bias but are nonetheless widespread research practice (Khazanchi, Lewis and Boyer, 2007).

Based on the Oslo Manual, five different innovation types are employed: Incremental product, radical product, process, marketing and organizational innovations. Each innovation construct is measured by its original measurement items, which are developed accordingly. Therefore, the innovation measures used in this research are new for the literature and hence require validation. The items of the innovativeness are presented in ***Table 1***.

{Insert Table 1 Around Here}

Questions regarding the importance of each operations priority for a firm use a 5-point Likert scale ranging from 1=extremely unimportant to 5= extremely important. Here we adopt the widely used statements of the competitive dimensions of manufacturing as the operations priorities of cost, quality, flexibility and delivery/dependability. In the questionnaire, these operations priorities are further subdivided into their relevant components. The scales of the four different operations priorities' measures are adapted from the existing OM literature with six, six, seven, and six criteria, respectively for cost, quality, flexibility, and delivery/dependability. The base of items asked regarding these priorities is adapted mainly from the literature (Vickery et al. 1993; Noble, 1997; Ward et al., 1998; Kathuria, 2000; Boyer and Lewis, 2002; Alpkan et al., 2003). ***Table 2*** presents these items.

{Insert Table 2 Around Here}

Three different performance measures are employed to expose the effects of realized innovations on firm performance, namely, financial, production, and market performances. Production performance, market performance, and financial performance scales are adapted from existing academic literature with four, three and four criteria, respectively. The base of items asked regarding these performance criteria is adapted mainly from the literature (Barringer and Bluedorn, 1999; Hornsby et al., 2002; Narver and Slater, 1990; Yılmaz et al., 2005). The items are tabulated in ***Table 3***.

{Insert Table 3 Around Here}

The questions about firm performance attempt to reveal the managers' perception of the firm performance in the last 3 years compared to the previous years' performance. A 5-point Likert scale is used with the scale ranging from 1= extremely unsuccessful to 5= extremely successful. The rationale for this subjective scale is reluctance of both firms to disclose exact performance records, as well as managers to share objective performance data (Boyer et al., 1997; Ward and

Duray, 2000). Conversely, top managers, who are well-acquainted with performance data, can provide more precise subjective evaluations (Choi and Eboch, 1998).

4. ANALYSES

The multivariate data analysis is performed in two stages. In the first stage, Principal Component Analysis (PCA) with varimax rotation is applied in order to reduce the larger set of variables into a more manageable set of scales (Flynn et al., 1990). The factors are named to represent as closely as possible the included variables. This stage is concluded by exploring internal consistency and reliability (content validity) among items of each construct via Cronbach α (Carmines and Zeller, 1979). Moreover, convergent validity between the innovation constructs is also examined and verified by the average-variance extracted (AVE) test (Fornell and Larker, 1981). The second stage corresponds to the cluster analysis of firms according to the 5 innovation types stated above. The resulting innovation clusters are then compared regarding operations priorities and corporate performance using ANOVA and post-hoc tests.

4.1. Stage 1: Factor Structures

For the PCA of innovativeness (there are 24 variables), Bartlett's test is conducted to assess the overall significance of the correlation matrix. As a result, the Chi-square score is 2188.3 with 276 degrees of freedom and the p-value is <0.01. Therefore, we reject the null hypothesis that variables are uncorrelated in the population. The KMO score is 0.902, which validates that correlation matrix is appropriate. The PCA on innovations extracted 5 factors with eigenvalues > 1 (***Table 1***). Moreover none of the items are eliminated since communality is over 0.5. The total variance explained is 63.741%. The Cronbach α values are ≥ 0.7 suggesting construct reliability (Saunila and Uko, 2014). In our case, the smallest AVE score is found as 0.774 indicating an adequate convergent validity since it is above the threshold value of 0.5 proposed by Fornell and Larker (1981).

Similarly, for the PCA of operations priorities (there are 25 variables), Bartlett's test is implemented to assess the overall significance of the correlation matrix. As a result, the Chi-square score is 1557.1 with 190 degrees of freedom and $p<0.01$. We therefore reject the null hypothesis that variables are uncorrelated in the population. The KMO score of 0.838 validates the appropriateness of the correlation matrix (***Table 2***). After omitting five variables with communalities <0.5, PCA produced 4 factors with latent root criterion and the average of communalities was 0.601. Here, the smallest AVE score is 0.750 which is again greater than the above mentioned threshold value of 0.5 indicating adequate convergent validity and Cronbach α values range from 0.843 to 0.770, suggesting satisfactory levels of construct reliability.

In the Bartlett's test for PCA of corporate performance (there are 11 variables), the chi-square score is found as 1132,258 with 55 degrees of freedom and the *p*-value is <0.01 (***Table 3***). We therefore reject the null hypothesis that variables are uncorrelated in the population. The KMO score is 0.837 validating the appropriateness of the correlation matrix. The PCA on corporate performance results in three factors with eigenvalues > 1. PCA results in 3 factors with eigenvalues > 1 and the average of communalities is 0.707. The smallest AVE score is 0.636 suggesting adequate convergent validity and the Cronbach α values range from 0.930 to 0.711 suggesting satisfactory levels of construct reliability.

4.2. Stage 2: Cluster Analysis

A five dimensional cluster analysis is then performed in order to form a taxonomy of the firms based on their innovativeness. A hierarchical procedure based on Ward's agglomerative method is used with the squared Euclidian distance measure. The elbow criterion is employed as a stopping rule (Hair et al., 2006) and the inspection of percentage change in clusters suggests a four-cluster solution. These four clusters are then examined according to their differences and managerial interpretability. The ANOVA is performed to test differences across the clustering variables by group mean. The clusters obtained are labeled as: Followers (82 firms), Inventors (35 firms), Leading Innovators (41 firms) and Laggers (22 firms).

After firms are clustered based on their innovativeness, resulting clusters are compared regarding the operations priorities and corporate performance (***Table 4, 5*** and ***6***, respectively). Note that these comparisons involve ANOVA test with Bonferroni post-hoc pair-wise comparison test aiming to clarify which groups significantly differ from each other in terms of their priorities and firm performance.

5. RESULTS AND DISCUSSIONS

5.1 Cluster Analysis of Innovativeness

The cluster means of each resulting category in terms of five innovation types are tabulated in ***Table 4***. The ANOVA analysis yields that the cluster means of the categories significantly differ in terms each innovation type. Furthermore, the Bonferroni test indicates that even the pair-wise comparisons significantly differ for each cluster mean with respect to the innovation types--with two exceptions (Followers and Inventors in terms of Incremental Product and Marketing

Innovations). A striking observation is the relatively low levels of marketing and organizational innovations except in the case of Leading Innovators. Ignoring a few exceptions, these innovation types are either not implemented or based on imitation. ***Figure 2*** depicts the distribution of the innovativeness values for each cluster in each innovation type.

On the other hand, the clusters are also tested against the control variables, namely, firm age, total sales, firm size, ownership status and existence of some level of foreign investment. Kruskal-Wallis Test is used for the former two control variables and Chi-Square Test is used for the latter three control variables. Note that both of the tests are nonparametric and does not assume normality and applicable to data sets that are nominal or ordinal (Levine et al. 2008). The results reveal that in terms of firm age, firm size, ownership status and existence of some level of foreign investment there is no statistically significant difference among the clusters. On the other hand, in terms of total sales the difference among the clusters is statistically significant (with p=0.10). Note that, the difference among the clusters in terms of the total sales is discussed in more detail later in subsection 5.3.

{Insert Table 4 Around Here}

{Insert Figure 2 Around Here}

5.1.1 Leading Innovators

Leading Innovators outclass others in every aspect of innovativeness trying to nurture all innovation types, even the incremental product innovations, where their mean score is the lowest (3.80). They give in particular higher importance to radical product and process innovations.

5.1.2 Followers

The Followers cluster is arguably the second most innovative cluster except for their very low radical product innovations capability (1.71), which is nearly equal to that of Laggers and far below that of Inventors. Clearly, Followers prefer to develop incremental product innovations (their highest score with 3.29) rather than radical ones. They are also relatively strong at process and organizational innovations.

5.1.3 Inventors

Inventors perform significantly better than Laggers and significantly worse than Leading Innovators in terms of all the innovation types. Inventors, however, have very strong radical product innovativeness. It appears that a key characteristic of Inventors is their focus on radical product innovations. They differ significantly from Followers in that respect. However, Followers perform significantly better than do Inventors in terms of the process and organizational innovations.

5.1.4 Laggers

The Laggers constitute the least innovative cluster. They have the lowest scores in all innovation types among the clusters. In all types of innovations Laggers either do not implement any innovations or imitate innovations from national and/or international markets. It can be said that Laggers seem not to prefer innovativeness as a component of firm strategy and do not rely primarily on innovations for competitive advantage.

5.2 Analysis Regarding to Operations Priorities

As stated earlier, the first hypothesis is whether the different innovation clusters adopt different operations priorities. Thus, the null hypothesis of the corresponding ANOVA analysis is that mean scores for the operations priorities of the resulting clusters are equal. ***Table 5*** tabulates the operations priorities of the resulting innovation clusters as well as the results of the ANOVA analysis and the pair-wise tests. The significant difference in terms of quality, flexibility and delivery with respect to the four distinct innovation clusters supports *H1* that different innovation clusters adopt different operations priorities.

{Insert Table 5 Around Here}

Figure 3 displays the box-plots of the operations priorities in terms of the clusters. The vertical axes represent the 95% confidence intervals of operations priorities scale and the horizontal axes signify the clusters of Leading Innovators, Followers, Inventors, and Laggers, respectively. The little circles on the box-plots represent the cluster means. Note that the resulting box-plots also visually reveal the significance of the innovativeness for operations priorities, since more innovative clusters tend to have higher scores on operations priorities.

{Insert Figure 3 Around Here}

Based on the results tabulated in ***Table 5,*** we can state that Leading Innovators distinguish themselves in all categories of operations priorities. Their average scores are the highest among innovation clusters in terms of each operations priority. This result supports the sand-cone model and the ambidexterity literature and suggests that the companies that have the highest innovativeness also have multiple concentrations of operations priorities. Furthermore, the pair-wise comparisons indicate that they emphasize quality (4.80) and flexibility (4.01) significantly more than do Laggers. Note that this result parallels those of earlier researches (Alegre-Vidal et al., 2004). Leading Innovators also focus on flexibility and delivery (4.55) significantly more than do Followers and significantly focus on quality more than do Inventors.

Followers differentiate themselves from Inventors and Laggers on the average, in terms of cost efficiency and quality rather than flexibility and delivery, which is again in line with the existing research (Utterback and Abernathy, 1975; Baldwin and Johnson, 1996; Alegre-Vidal et al., 2004). Followers have both high quality and high cost efficiency capabilities (4.69 and 4.40, respectively), but their delivery level is one of the lowest (4.29) among the clusters. They focus most on quality but care less for flexibility (3.61).

Quality (4.55) is the most focused on operations priority for Inventors as it is the case for other innovation clusters. However, as opposed to Followers, Inventors attach the same level of importance to delivery (4.30) and cost efficiency (4.30). Note that Inventors are at the second place for delivery and flexibility and at the third place in cost efficiency and quality. Thus, with respect to each other, Followers focus more on cost efficiency and quality; Inventors, on flexibility and delivery. The box-plots presented in ***Figure 3*** also demonstrate that firms in the Inventors cluster emphasize flexibility more than the firms in the Followers cluster. Given that Inventors have higher radical product innovativeness than the Followers, focusing on flexibility is an appropriate selection for those companies.

The Laggers are the weakest cluster in terms of the cluster means with respect to each one of the operations priorities. The Laggers compare with the Followers and the Inventors only in delivery, where the clusters all have very similar scores. One interesting observation is the fact that Laggers give more importance to delivery (4.29) than cost efficiency (4.18) on the average as opposed to the Followers.

In general, the box-plots presented in ***Figure 3*** display an increasing confidence interval when moving from the Followers cluster to the Laggers cluster over all operations priorities. Note that smaller confidence intervals imply more uniform performance among the firms within a cluster.

5.3 Analysis Regarding to Corporate Performance

As stated earlier, the second hypothesis regards whether the different innovation clusters also differ in terms of the corporate performance. ***Table 6*** tabulates the performance of the resulting innovation clusters in terms of three performance factors as well as the results of the ANOVA analysis and the Bonferroni tests. The null hypothesis of the ANOVA tests is that mean scores of the resulting innovation clusters are equal for production, market, and financial performances. Note that two additional independent variables based on objective data are introduced to complement the financial performance component. These are total sales (Million Euro-M€) and growth of total sales (%). These variables are tested by Kruskal-Wallis Test, since normality assumption does not hold for these variables. ***Figure 4*** displays the box-plots of corporate performance constructs with respect to the resulting innovation clusters. The vertical axes represent 95% confidence intervals of the performance items; horizontal axes signify different clusters.

{Insert Table 6 Around Here}

{Insert Figure 4 Around Here}

The differences in production and market performances, total sales and growth on total sales of innovation clusters support *H2,* different innovation clusters achieve different operational and financial performance levels.

In terms of the cluster means of the corporate performance measures, Leading Innovators have better production, market, and financial performance levels. Their total sales are significantly higher than those of Inventors and Laggers and on the average double those of Followers. The growth in total sales of Leading Innovators is second best following Inventors. Followers have attained the second best level for financial performance and total sales after the Leading Innovators. They have a strong market and production performance (3.90 and 3.85, respectively). Their growth rate in total sales is also acceptable with 22.4% annually. Inventors are the second highest performers after Leading Innovators in terms of market and production performance. More importantly, Inventors have the highest annual growth rate in total sales (30.9%). Laggers not only have a relatively weak position in terms of innovativeness and operations priorities but also have the worst performance scores in terms of the market and production performances as well as the growth rate for total sales, which is only 12.5% annually. Note that the mean growth rate of the remaining three clusters is 25.9%.

The box-plots in ***Figure 4*** also confirm the association of higher innovativeness with higher performance. For instance, for the market performance of all, three innovation clusters are much better than the Laggers cluster. The Followers cluster outperforms the Inventors cluster only in financial performance. Finally, the Leading Innovators cluster is again the dominant cluster with highest performance results in all aspects of the corporate performance. Similar to the operations priorities case, the confidence intervals here increase as well when moving from the Followers to the Laggers.

6. CONCLUSIONS

The findings substantiate that manufacturing firms can be clustered according to their innovativeness; moreover, the clusters can provide a taxonomy of innovativeness which reveals how innovation clusters adopt and develop different operations priorities and attain diverse corporate performance levels.

The results obtained led us to managerial insights around which various strategies might evolve. The majority of the innovation and operations strategy literature affirm that operations priorities and innovations are the crucial components of corporate strategies and are among the primary drivers behind different performance levels (Damanpour, 1987; Hayes et al., 1988; Boyer and Lewis, 2002; Sum et al., 2004; Gunday et al., 2008). Our results support the notion that innovativeness is associated with better corporate performance. More precisely, Laggers cluster does not rely on innovativeness and also has the lowest operations and performance results. In the other extreme, the most innovative cluster, Leading Innovators, exploits all aspects of the operations priorities and demonstrates the best overall corporate performance.

The need for pervasive innovation within a firm becomes clear with the positioning of Leading Innovators. As suggested earlier, they outclass others in every aspect of innovativeness trying to nurture all innovation types. To excel both in technological (product and process) and non-technological (marketing and organizational) innovations, the belief in innovation must diffuse in all aspects of an organization and not be limited to certain groups and/or departments in the firm.

As Innovation and innovativeness are so vital for corporate performance and competitiveness, there is a need to approach them in the context of an innovation strategy, which conceives manufacturing strategy as a component of business strategy. Innovation and innovativeness in a firm should also be nurtured based on an innovation strategy with a 3-5 years rolling time horizon. When managing and directing such a strategy, a crucial requirement among others would be to employ well defined and transparent performance criteria and input and output innovation metrics (McKinsey Global Institute, 2008).

All these findings show the vital role of innovativeness for manufacturing firms as closely linked with operations priorities and corporate performance. Leading Innovators compete effectively on simultaneously prioritizing multiple operations. Hence, firms must excel in multiple priorities and innovations in their market rather than concentrate on a single operations priority and innovation type. These findings strengthen the results presented earlier by Ferdows and De Meyer (1990), Roth and Miller (1992), Miller and Roth, (1994), Kathuria (2000) and Avella et al. (2011) suggesting that firms may be competent in multiple operations priorities. On the other hand, Followers on the average focus on cost and quality more than do Inventors, who focus on delivery and flexibility more than do Followers, yet there is no significant difference in terms of their performance. That is to say, the co-existence of a focused factory approach also hints that the two models are not competing but complementary, thus supporting the integrative model.

Alternative strategies provide diverse levels of benefits to the enterprises; thus, there are alternative ways to compete in the market even within the same industry. The comparison of Followers and Inventors in terms of their operations priorities and corporate performance suggests in particular that each aspect of the innovative capability is important and offers some degree of competitive advantage. Recall that Inventors emphasize more the development of radical product innovations, they focus on the flexibility more than do Followers and are the leaders in total sales growth rate and the second best performer in production and marketing performance. On the other hand, Followers do not prefer to develop radical products but give balanced importance to process, organizational, and incremental product innovations.

A conclusion concerning the benefit of an analysis based on taxonomy is that it allowed us to reveal the shades of grey as opposed to the more monochromatic dichotomous approach to innovativeness, and thus suggest the reason for the contradictory results available in the literature. For example, consider a possible dichotomous analysis (high vs. low innovativeness) based on only product innovativeness. In such an analysis, the majority of Followers and Inventors would be classified as highly innovative firm(s) together with Leading Innovators (***Table 4***). On the other hand, Laggers would be classified as firms with lower innovativeness. Since Followers and Inventors would dominate the High Innovative firms set (in terms of numbers), the results regarding firm performance would differ; the conclusion would be that no statistical significance exists between High vs. Low innovativeness in terms of the firm performance. However, an analysis based on more elaborate taxonomy, reveals the statistically significant distance between Leading Innovators and Laggers.

There are some limitations of our study. Firstly, the survey reflects the current environment. A longitudinal study may lead to more accurate taxonomy of innovativeness and its impact on operations priorities and firm performance. Secondly, the study is conducted across the manufacturing industries. It would be worthwhile to conduct a comparative cross-sector analysis of the manufacturing sectors involved by employing a larger sample. Thirdly, the study is limited only to the manufacturing sector and excludes other sectors such as primary ones such as mining, forestry and service. Finally the data set in the study is gathered from a single country. It would be valuable to conduct the study in different countries for a comparative study.

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Table 1: PCA of innovativeness

Factors	Factor Loads	Eigen-value	Cum. % variance explained	Cronbach α	AVE
Factor 1: Organizational Innovations		9.027	37.613	0.896	0.783
Renewing the organization structure to facilitate teamwork	0.763				
Renewing the organization structure to facilitate coordination between different functions such as marketing and manufacturing	0.736				
Renewing the organization structure to facilitate project type organization	0.736				
Renewing the routines, procedures and processes employed to execute firm activities in innovative manner.	0.711				
Renewing the human resources management system.	0.679				
Renewing the production and quality management system.	0.685				
Renewing the supply chain management system.	0.629				
Renewing the organizational structure to facilitate strategic partnerships and long-term business collaborations	0.501				
Renewing the in-firm management information system and information sharing practice	0.494				
Factor 2: Marketing Innovations		2.181	46.700	0.835	0.785
Renewing the distribution channels without changing the logistics processes related to the delivery of the product	0.720				
Renewing the product pricing techniques employed for the pricing of the current and/or new products	0.709				
Renewing the product promotion techniques employed for the promotion of the current and/or new products	0.700				
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	0.638				
Renewing general marketing management activities.	0.632				
Factor 3: Process Innovations		1.803	54.214	0.820	0.830
Determining and eliminating non value adding activities in delivery related processes	0.713				
Decreasing variable cost and/or increasing delivery speed in delivery related logistics processes	0.681				
Decreasing variable cost components in manufacturing processes, techniques, machinery and software.	0.675				
Determining and eliminating non-value adding activities in production processes	0.648				
Increasing output quality in manufacturing processes, techniques, machinery and software	0.634				
Factor 4: Incremental Product Innovations		1.251	59.426	0.701	0.774
Introducing innovations in components and materials of current products to increase product quality	0.666				
Introducing innovations in current products leading to improved ease of use and improved customer satisfaction	0.658				
Introducing innovations in components and materials of current products to decrease product cost	0.656				
Factor 5: Radical Product Innovations		1.036	63.741	0.799	0.854
Developing new products with technical specifications and functionalities totally different from the current ones	0.800				
Developing new products with components and materials totally different from the current ones	0.714				
KMO Measure of Sampling Adequacy = 0.902; Bartlett Test of Sphericity = 2188.3; $p<.000$.					

Table 2: PCA of operations priorities

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: 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 machine and equipment priorities when necessary	0.657				
Increase in ability of flexible production	0.484				
Factor 3: 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 completion of delivery	0.744				
Increase in ability to meet the delivery commitments	0.718				
Decrease the makespan from taking the orders to the completion of delivery	0.707				
Increase in just in time delivery	0.631				
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 = 1557.127; p<.000.

Table 3: PCA of corporate performance

Factors	Factor Loads	Eigen-value	Cum. % variance explained	Cronbach α	AVE
Factor 1: Financial Performance		4.699	42.716	0.930	0.932
Return on assets (profit/total assets)	0.920				
General profitability of the firm	0.915				
Return on sales (profit/total sales)	0.900				
Cash flow excluding investments	0.790				
Factor 2: Market Performance		1.954	60.475	0.766	0.732
Customer satisfaction	0.807				
Market share	0.715				
Total sales	0.708				
Factor 3: Production Performance		1.121	70.666	0.711	0.636
Production (volume) flexibility	0.760				
Production cost	0.750				
Production and delivery speed	0.702				
Conformance quality	0.553				
KMO Measure of Sampling Adequacy = 0.837; Bartlett Test of Sphericity = 1132.258; p<.000					

Table 4: Innovation clusters and their innovativeness

Innovativeness	Leading Innovators (Cluster 1)	Followers (Cluster 2)	Inventors (Cluster 3)	Laggers (Cluster 4)	F (or K)
Incremental product innovations					
Cluster mean	3.80[a] (2,3,4)[b]	3.29 (1,4)	3.14 (1,4)	1.44 (1,2,3)	45.89[c] *p*<0.000
Radical product innovations					
Cluster mean	4.17 (2,3,4)	1.71 (1,3,4)	3.74 (1,2,4)	1.14 (1,2,3)	130.10[d] *p*<0.000
Process innovations					
Cluster mean	4.17 (2,3,4)	3.04 (1,3,4)	2.27 (1,2,4)	1.67 (1,2,3)	41.09[c] *p*<0.000
Marketing innovations					
Cluster mean	3.88 (2,3,4)	2.40 (1,4)	2.11 (1,4)	1.28 (1,2,3)	64.26[c] *p*<0.000
Organizational innovations					
Cluster mean	3.92 (2,3,4)	2.93 (1,3,4)	2.21 (1,2,4)	1.62 (1,2,3)	67.15[c] *p*<0.000

Notes: [a] Mean based on comparing the last 3 years' innovativeness performance with the previous years' innovativeness performance. [b] Numbers in parentheses indicate the cluster groups from which this cluster is significantly different at α=0.05. [c] F and corresponding *p*-values based on ANOVA test. [d] Radical product innovation test statistic is based on Kruskal Wallis test.
Underlined values indicate significance at α=0.01.

Table 5: Innovation clusters and their operations priorities

Operations Priorities	Leading Innovators (Cluster 1)	Followers (Cluster 2)	Inventors (Cluster 3)	Laggers (Cluster 4)	F (or K)
Cost					
Cluster mean	4.50[a]	4.40	4.30	4.18	1.96[c] *p*<0.121
Flexibility					
Cluster mean	4.01 (2,4)	3.61 (1)	3.87	3.55 (1)	3.67[c] *p*<0.013
Delivery					
Cluster mean	4.55 (2)	4.29 (1)	4.30	4.29	2.18[c] *p*<0.092
Quality					
Cluster mean	4.80 (3,4)[b]	4.69	4.55 (1)	4.53 (1)	3.14[d] *p*<0.042

Notes: [a] Mean based on comparing the last 3 years' operations performance with the previous years' operations performance. [b] Numbers in parentheses indicate the cluster groups from which this cluster is significantly different at α=0.1. [c] F and corresponding *p*-values based on ANOVA test. [d] Quality test statistic is based on Kruskal Wallis test.
Underlined values indicate significance at α=0.1.

Table 6: Innovation clusters and their corporate performance

Corporate Performance	Leading Innovators (Cluster 1)	Followers (Cluster 2)	Inventors (Cluster 3)	Laggers (Cluster 4)	F (or K)
Production performance					
Cluster mean	4.01 (4)	3.85	3.91	3.51 (1)	2.18[c] p<<u>0.094</u>
Market performance					
Cluster mean	3.99 (4)	3.86	3.91	3.39 (1)	2.23[c] p<<u>0.087</u>
Financial performance					
Cluster mean	3.42	3.32	3.06	3.13	1.23[c] p<0.300
Total Sales					
Cluster mean	60.8 M€ (3,4)	26.8 M€	7.3 M€ (1)	13.0 M€ (1)	11.557[d] p<<u>0.009</u>
Growth of Total Sales					
Cluster mean	24.4%	22.4%	30.9%	12.5%	1.99[d] p<0.573

Notes: [a] Mean based on comparing the last 3 years' operations performance with the previous years' operations performance. Numbers in parentheses indicate the cluster groups from which this cluster is significantly different at α=0.1. [c] F and corresponding p-values based on ANOVA test. [d] Total sales and growth of total sales test statistics are based on Kruskal Wallis test.
Underlined values indicate significance at α=0.1.

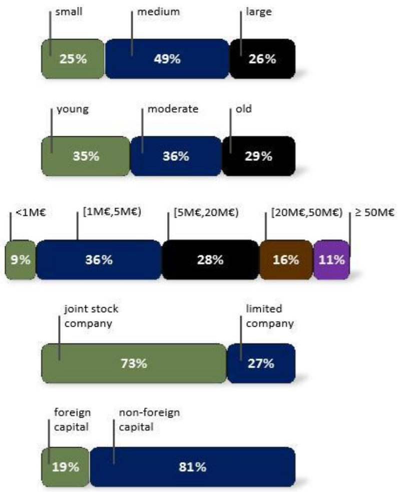

Figure 1: Sample profile

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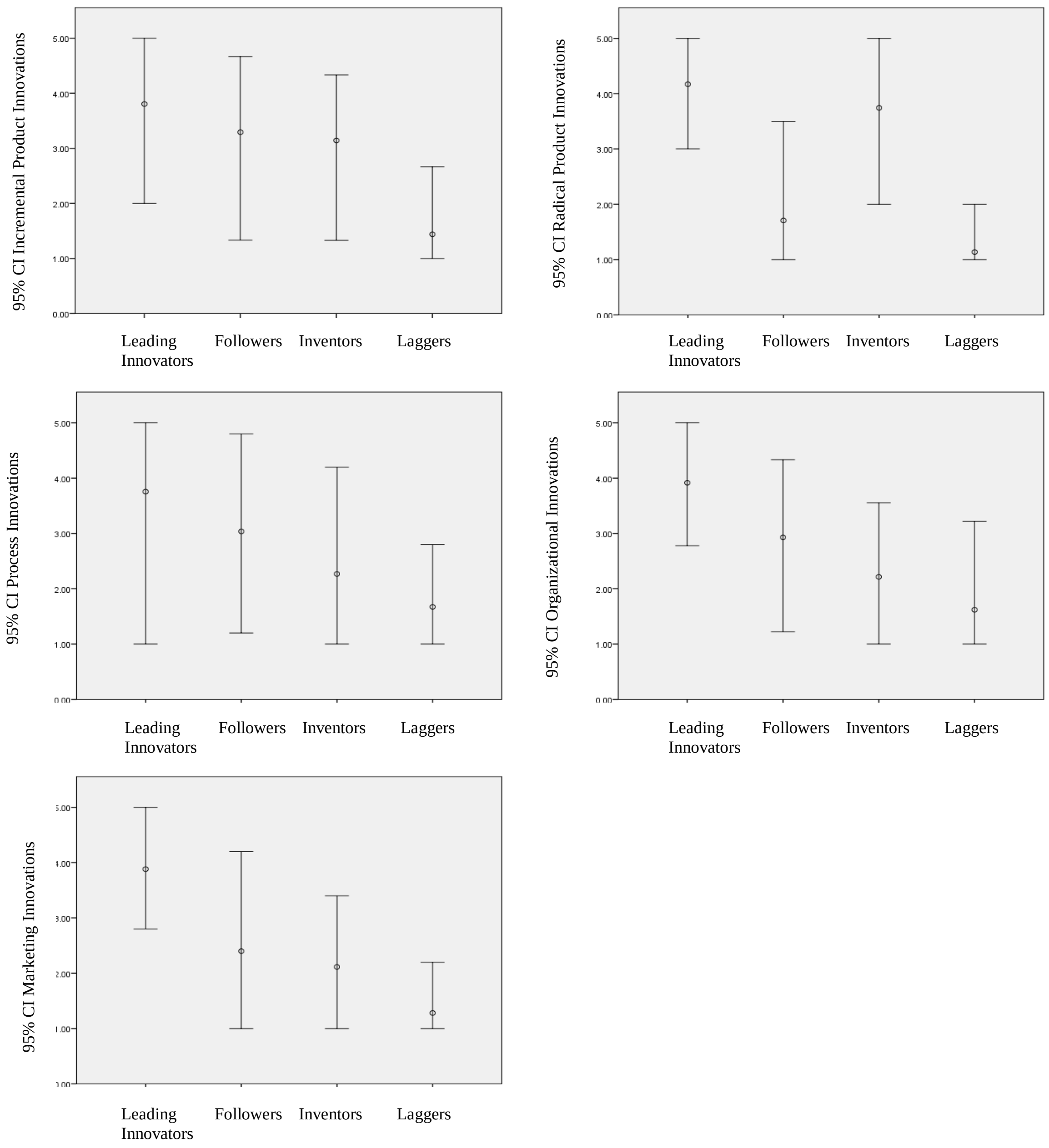

Figure 2: Box-plots of innovativeness

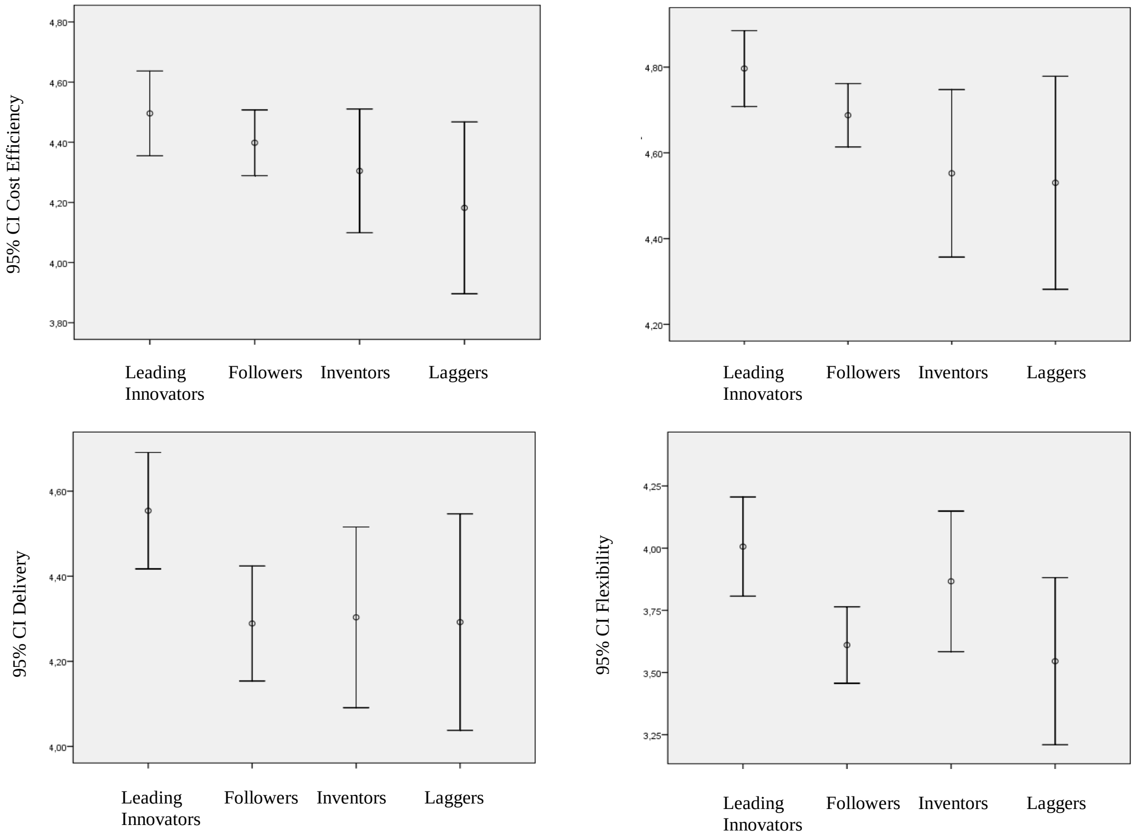

Figure 3: Box-plots of operations priorities

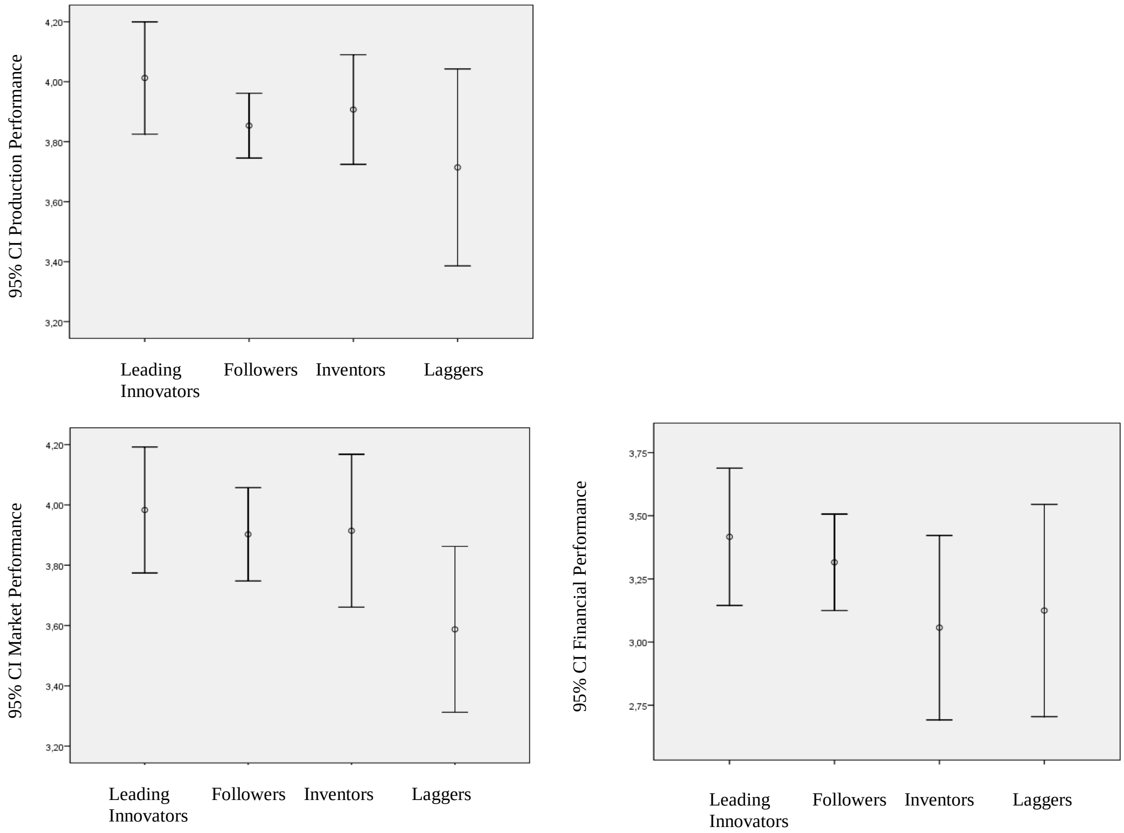

Figure 4: Box-plots of corporate performance factors