WHAT ARE THE DETERMINANTS LEADING TO INNOVATION IN MANUFACTURING FIRMS[1]

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In this paper, a comprehensive model of innovation determinants is analyzed based on empirical data gathered from 184 manufacturing firms located in the Northern Marmara region in Turkey. As opposed to the studies that establish the relationship with a limited set of antecedents and innovativeness, this study allows us to investigate how significant is an antecedent compared to others. Such knowledge is invaluable for the decision makers in order to manage their innovation strategies and provides a guideline for effective allocation of their limited resources to be more innovative. The analysis reveals that among all possible determinants considered, intellectual capital has the highest impact on innovativeness followed by organization culture. Path analyses for both of these major innovation determinants are investigated in detail. Some managerial implications are suggested.

Keywords

Empirical research; Innovation; Innovation determinants; Innovativeness model; Manufacturing industry.

1. Introduction

Effective management of innovative organizational climate and capabilities have been generally accepted to help firms achieve higher customer value leading to sustainable competitive advantage in the innovation management literature. Thereby, a long list of organizational drivers of innovativeness, e.g., organization culture, intellectual capital, firm strategies, etc., came out. However, the findings are not always in parallel with each other and sometimes a driver found to be effective in one study proved to be ineffective in another. Moreover, almost all of the empirical studies concentrated on only some specific parts or aspects of this list without controlling the other drivers.

In this study, instead of trying to add some new drivers conceptually and test their effects empirically, most of the already confirmed drivers are tried to be adopted and their individual effects together -not separately is being tested. This approach leads to the measurement and comparison of the individual effect sizes of different antecedents of innovativeness simultaneously. This model will be used to select the most important factors that create an innovative environment in manufacturing firms and thus suggest policies to improve innovativeness at the firm level to the senior managers.

In section two the relevant literature and the comprehensive model will be presented. Section three will cover details about the data and the measurement of variables. The multivariate data analysis employed in this study will be explained in section four. After the discussion of the results of the path analyses leading to path models for intellectual capital and

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organization culture in section five, the paper will be concluded with further comments on managerial implications in section six.

2. Innovation and innovation determinants

Innovations can be considered as the successful development and application of new knowledge, with the purpose of launching newness into the economic area and transforming knowledge into profit. In this research, the OECD Oslo Manual [1], which is the primary international basis of guidelines for defining and assessing innovation activities as well as for compilation and use of related data, has been taken as the fundamental reference source to describe, identify and classify innovations at firm level. In the Oslo Manual, four different innovation types are introduced, namely, product, process, marketing and organizational innovations.

The results reported by Günday et al. [2] reveal that innovative companies perform better and are usually more competitive than their rivals. Some companies turn out to be more successful than the others in being innovative due to various internal and external factors they possess. These factors that affect the innovativeness (i.e., the innovative capabilities of the companies) are referred to as the innovation determinants.

2.1 Innovation determinants

Innovation determinants at firm level have been frequently discussed in the innovation management literature. The innovation determinants can be classified in two subgroups: in-firm (indigenous) parameters and out-firm (exogenous) parameters. The indigenous parameters include general firm characteristics (such as firm's age, size, ownership status etc.), intellectual capital (human capital, social capital, organizational capital), firm structure (formalization, centralization, communication), firm culture (firm decision making process and openness of in-firm communication channels, delegation of works, managerial support, reward system, etc.) and firm strategies (such as collaborations, knowledge management, investments strategies and cost strategies, pressure of competition elements, etc.). On the other hand, exogenous parameters are industrial conditions and relations (such as business sector and market structure, public regulations and incentives, external financial funds acquisition, and out-firm barriers to innovation).

Due to space limitations, the reader is referred to Ulusoy et al. [3] for a detailed discussion of these factors and their relevance to innovativeness.

2.2 Drivers of innovativeness model

Based on the literature that is reviewed in the previous section, one can conclude that the innovativeness in a firm is indeed a joint outcome of factors such as firm characteristics, firm structure, intellectual capital, firm strategies and external conditions. These innovation determinants with all their sub-elements are presented in a model designated as the drivers of innovativeness model (Figure 1).

In order to validate the drivers of innovativeness model, a questionnaire consisting of 311 individual questions was developed to be filled in by the upper managers of manufacturing companies. We will next discuss the data collection process and the methodology in more detail.

3. Data collection

After the questionnaire was developed, the initial survey draft was discussed with various firms' executives and it was pre-tested through 10 pilot interviews to ensure that the wording,

format and sequencing of questions are appropriate. Data was collected over a 7-month period using a self-administered questionnaire distributed to firms' upper level managers operating in manufacturing sectors in the Northern Marmara region in Turkey.

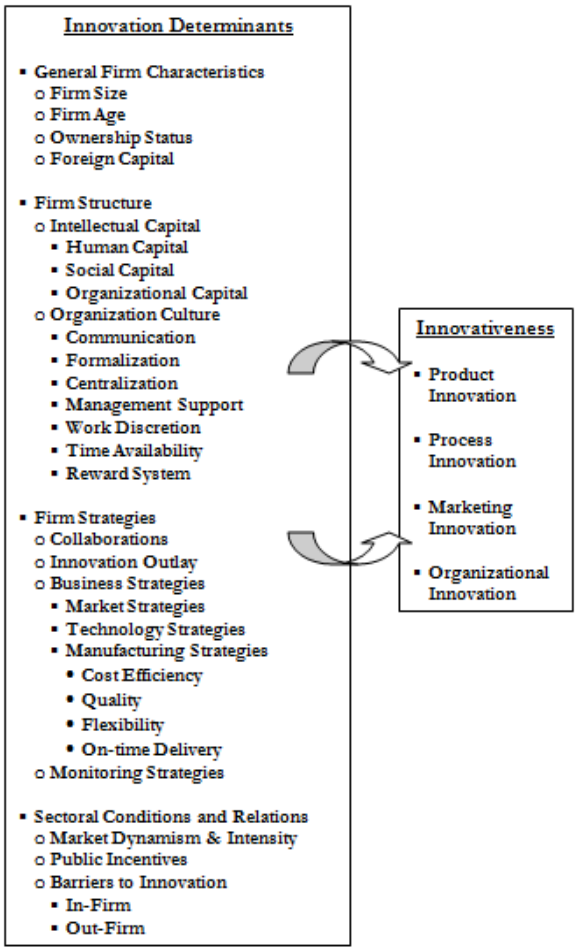

Figure 1 Drivers of innovativeness model.

3.1 Data collection

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A sample of 1,674 manufacturing firms was obtained by selecting randomly from the database of the Union of Chambers and Commodity Exchange (TOBB) and Istanbul, Kocaeli, Tekirdag, Cerkezkoy, and Sakarya Industry Chambers and member lists of various Industry Parks in Northern Marmara region within Turkey. When randomly drawing these firms from the larger sample, care was exercised to secure representative geographic and sector distributions of these firms within the larger sample. Data was collected over a 7 months period in six different manufacturing sectors (namely textile (20%), chemical (18%), metal products (19%), machinery (15%), domestic appliances (8%) and automotive industries (20%)), where the percentages reported correspond to the percentage of the firms surveyed in each sector within the total sample. For each sector, number of firms in the

sample turned out to be representative, since no significant difference ($p \leq 0.05$) has been detected between the population and sample percentages. Afterwards, the questionnaire was applied through a hybrid system of mail surveys and face-to-face interviews. Out of the sample of 1672 firms, 184 complete responses were obtained resulting in 11% return rate. The percentage of missing data across all data was calculated to be negligible. Occasional missing data were randomly distributed (MAR) on items.

The data was later controlled with t-test procedure for non-respondent bias (randomness of the data) and no significant difference ($p \leq 0.05$) was found 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 control variables. In the analyses, variables such as firm size, firm age, ownership status and foreign investments in the company were examined as control variables, since these organizational variables may have possible effects both on innovative capabilities and firm performance. Moreover, the issue of Common Method Variance (CMV) was also attended based on the Harman's single-factor test and it is shown that one cannot conclude the existence of CMV as a result.

Figure 2 depicts a profile of the resulting sample, illustrating its diversity in terms of annual sales volume, firm size (in terms of number of employees) and firm age. Firm size was determined by the number of full-time employees (up to 50: small; between 50 and 250: medium; 250 and above: large) and firm age is determined by the year production started (before 1975: old; between 1975 and 1992: moderate; 1992 and later: young). Annual sales volume was divided into 5 categories: less than 1M Euro; between 1M Euro and 5M Euro; between 5M Euro and 20M Euro; between 20M Euro and 50M Euro; and 50M Euro or more.

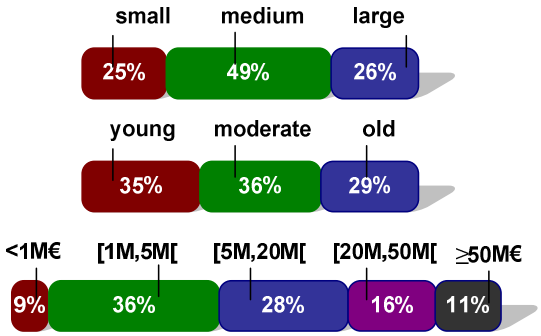

Figure 2 Sample profile.

After the data collection stage, multivariate statistical analyses via SPSS v17 and AMOS v16 software package were conducted in order to validate the research framework.

3.2 Measurement of variables

The questionnaire form is prepared by considering recent questionnaire forms utilized in similar studies and commonly accepted measures met in the current literature. Specifically, the questions about manufacturing strategies (operations priorities), organization culture, innovation barriers, intellectual capital, business strategies are 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 researches [4].

The scales of the four different manufacturing strategies' measures are adapted from existing operations management (OM) literature with six, six, seven, and six criteria, respectively. The base of items asked regarding these priorities are adapted mainly from Boyer and Lewis [5], Alpkan et al. [6], Noble [7], Ward et al. [8], Vickery et al. [9] and Kathuria [10]. For business strategy items, we also benefited from Olson et al. [11].

The scales of the three intellectual capital measures are constructed by inspiring from Subramaniam and Youndt [12] with five, five, and four criteria, respectively for the human capital, social capital and organizational capital. Similarly organizational culture measures are adapted from several criteria in OM literature based previous studies of Walker et al. [13], Jaworski and Kohli [14] and Menon et al. [15].

The questions about innovative capabilities are enquired employing a 5-point Likert scale. The respondents are 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 is adapted mainly from Oslo Manual [1]. Each innovation construct is measured by its original measurement items, which are developed accordingly. Note that the innovation measures used in this research are partially new for the literature and required to be validated during the analysis.

4. Multivariate data analysis

In order to extract the underlying relationships between the innovation determinants and the innovativeness, multivariate data analysis was conducted. First, a principal component analysis (PCA) with varimax rotation is conducted using SPPS in order to identify the underlying innovation determinants and dimensions of innovations, which was followed by a second order PCA in order to reduce the obtained items to usable size and to achieve a more manageable set for subsequent structural equations modelling analysis (SEM) analysis. Five innovation determinants constructs were obtained; namely, organization culture, barriers to innovation, firm manufacturing strategy, intellectual capital and collaboration. Details of this stage are reported in Günday et al. [16]. This stage is concluded by exploring internal consistency and reliability (content validity) among the items of each construct via Cronbach α and unidimensionality tests.

The constructs reported above did not fully overlap with the structure foreseen in the drivers of innovativeness model. For example, we hypothesized that Intellectual Capital and Organization Culture are subparts of another construct which was referred to as the Firm Structure. However, the factor analysis results implicated that, the items that compose these constructs can't be grouped under a single construct and should be treated as two different constructs. Similarly, the formalization item was hypothesized to be part of the organization culture. However, the factor analysis placed formalization under the intellectual capital construct and hence, it was eliminated in the SEM analysis. Furthermore, some of the constructs such as the market dynamism and intensity, public incentives, and monitoring strategies were excluded from the SEM analysis since they were deteriorating the underlying factor structure.

The second stage involved the relationships between the factors explored through the correlation and regression analyses and SEM. SEM procedure obtains weights, loadings and path estimates while performing an iterative scheme of multiple regressions until they converge to a solution.

Since some of the innovation determinants such as the general firm characteristics (i.e., size, age, ownership status and foreign capital) 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 thing is true for the marketing and technology strategies. Therefore, it was preferred not to include them to the SEM analysis. The firm characteristics were treated as control variables and more appropriate statistical analysis (correlation analysis, t-tests, ANOVA, etc.) were conducted in order to assess their effect to the innovativeness at the firm level.

A single-step SEM analysis with the simultaneous estimation of both measurement and structural models was conducted using AMOS v16. The measurement model of SEM is

based on the comparison of the variance-covariance matrix obtained from the sample to the one obtained from the model [17]. The entire model is supported with the goodness-of-fit indices. (Further details can be reached in Ulusoy et al. [3]). Each relation in the model is statistically significant ($p<0.05$). As a result, the proposed paths of relations matching innovation determinants to innovativeness are analyzed and validated regarding their significant path (regression) estimates. According to the path estimates obtained by the SEM analysis, intellectual capital is observed to be the strongest driver of innovative capabilities. It is followed by organization culture, collaborations, barriers to innovation, and firm manufacturing strategies. The barriers to innovation construct is found to be significantly and negatively correlated to innovativeness.

In the following section, we will report the results of the path analyses leading to path models for intellectual capital and organization culture -the two most effective drivers of innovative capabilities. A detailed account of business strategies, which is comprised of firm manufacturing strategy, technology development and market focus, can be found in Ulusoy et al. [18].

The path analysis models in the following section have a common endogenous variable (dependent variable): the innovativeness. The models are formed employing AMOS v4.0 and analyzed according to SEM method. In the figures displaying these path models, the estimates on the arrows are regression weights and the estimates on the box corners are the squared multiple correlations.

5. Results

5.1 Intellectual capital

As a result of explanatory factor analysis, intellectual capital is represented by three factors; namely, human capital, social capital, and organizational capital. The findings of the correlation analysis extract significant one-to-one positive relationship of the aggregated factors. All intellectual capital factors correlate significantly to innovativeness scale with $p<0.01$ (Table 1). Organizational capital has the higher correlation coefficient ($r=0.518$) and human capital the lower correlation coefficient ($r=0.271$). Very high correlation of organizational capital stresses the major importance of this factor for firms in order to be more innovative. Hence, correlation analysis demonstrates the positive relationship between innovativeness and intellectual capital. However, this analysis cannot say much about the direction (cause) of the relationship. For that purpose, the multiple linear regression (MLR) analysis can provide more insight.

The regression model of the effects of intellectual capital on innovativeness is statistically significant ($p<0.01$) and according to this model, the independent variables express 28.0% ($R^2=0.280$) of innovativeness. High R^2 of the model and high regression coefficient of organizational capital ($\beta=0.495$) indicate that intellectual capital and especially organizational capital have supreme importance for innovative capability. However, when the factors are included jointly in the MLR, only organizational capital ($\beta=0.495$; $p<0.01$) and human capital ($\beta=0.144$; $p<0.1$) result in significant positive effects. On the other hand, when entered separately, all intellectual capital factors were significantly and positively correlated to innovativeness. So, despite the fact that the model is significant, MLR analysis reveals only some intellectual capital factors have statistically significant effects on innovativeness. This finding implies that there are mediating effects between intellectual capital variables.

Table 1 Correlation analysis of intellectual capital.

	Mean	Std Dev	1	2	3	4
1. Innovativeness	2.81	0.84	1	0.295**	0.271**	0.518**
2. Human capital	3.62	0.65		1	0.582**	0.389**
3. Social capital	3.65	0.59			1	0.498**
4. Organizational capital	3.41	0.88				1

(**) p<0.01

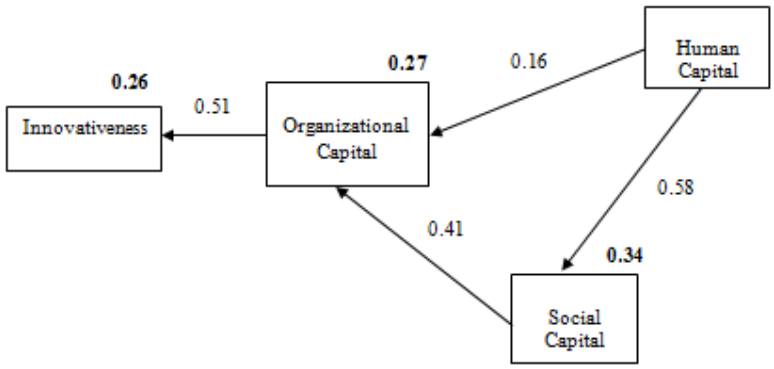

Figure 3 Path analysis model for intellectual capital.

Post hoc analysis suggests that organizational capital mediates the other intellectual capital factors' effects on innovativeness. The resulting path analysis model with its significantly consistent findings is displayed in Figure 3. 26% of the innovativeness can be explained by that model.

Human capital deals with the intelligence, talent, creativity, specialization and productivity of the human resources available. It indeed constitutes the basis of intellectual capital of an organization. Participation of human resources in communication and knowledge sharing; problem detection, formulation and solution; collaboration along these lines among themselves and with customers and suppliers; and acting as part of a learning organization are all encompassed by social capital. Accumulation of experience and knowledge and their reflection to conventions, methods, and processes, and their documentation are the components of organizational capital. As it is revealed in Figure 3 and the definition of the factors given above, it follows that human capital constitutes the basis of both social and organizational capital. Furthermore, social capital influences organizational capital. Innovativeness is directly affected by organizational capital.

5.2 Organization culture

As a result of explanatory factor analysis, organization culture is found to consist of seven factors, namely, communication, formalization, centralization, management support, time availability, work discretion, reward system. The findings of the correlation analysis extract significant one-to-one positive relationship of the aggregated factors (Table 2). All organization culture factors correlate significantly to innovativeness scale with $p<0.01$ except formalization and centralization whose correlations are at $\alpha=95\%$ level. Management support has higher correlation coefficient ($r=0.382$), and formalization has lower correlation coefficient ($r=0.155$) with innovativeness. High correlation of management support to innovativeness stresses the major importance of managerial encouragement to idea generation and support to new projects, in order to be more innovative. Note that centralization is negatively

correlated to innovativeness as well as all the other factors. In summary, correlation analysis brings up the positive relationship between innovativeness and organization culture.

Table 2 Correlation analysis of organization culture.

	Mean	Std Dev	1	2	3	4	5	6	7	8
1. Innovativeness	2.81	0.84	1	.350**	.155*	-.192*	.382**	.226**	.219**	.340**
2. Communication	3.95	0.63		1	.293**	-.434**	.572**	.402**	.225**	.524**
3. Formalization	3.39	0.70			1	-.081	.321**	.029	.265**	.218**
4. Centralization	2.79	0.82				1	-.450**	-.332**	-.144	-.357**
5.Management support	3.53	0.68					1	.476**	.386**	.673**
6. Work discretion	3.23	0.75						1	.381**	.419**
7.Time availability	3.21	0.94							1	.405**
8. Reward system	3.68	0.93								1

(**) p<0.01; (*) p<0.05

For investigating the effects of organization culture on innovativeness, a regression model is obtained by applying MRL. The resulting regression model is statistically significant (p<0.01) and according to this model, the independent variables express 18.3% (R^2=0.183) of innovativeness. However, when organization culture factors are included jointly in the MLR, only communication (β=0.181; p=0.058) and management support (β=0.195; p=0.082) have significant positive effects on innovativeness. But when included individually, all organization culture factors are significantly and positively correlated to innovativeness. Therefore, despite the fact that the model is significant, there is mediating effect between organization culture factors.

Post hoc analysis suggests that communication, reward system and management support mediate other organization culture factors' effects on innovativeness. The results expose the positive relationship between organization culture and innovativeness. The resulting path analysis model is presented in Figure 4.

Formalization is at the root of the path analysis model. Formalization implies a well defined and documented and properly functioning organization designed as a hierarchy of authority. Formalization supports organizational capital. It should be noted that it has no overlap with centralization. As mentioned above, management support appears as the most influential factor on innovativeness. Considering that innovation implies change we can claim that innovation management is change management. Like any change management, such as total quality management, innovation management needs top management support to overcome the hurdles met on the way to success. Communication and reward system are the other two factors besides management support affecting innovativeness directly. Communication construct includes components like the openness of channels between various levels of the organization; open channels among employees on the same organization level as well as with suppliers and customers, well informed employees on strategies, plans, and changes concerning the firm; existence of mechanisms for acquiring ideas and feedback from the employees in the decision making process. Open communication appears to be an effective tool for the creation of an environment conducive for innovativeness. A merit based transparent reward system functioning according to openly declared rules, which are approved by well informed employees, also serves this purpose. The employees need to know that their efforts and contributions towards being innovative and thus increasing the innovativeness of the firm will be recognized and rewarded.

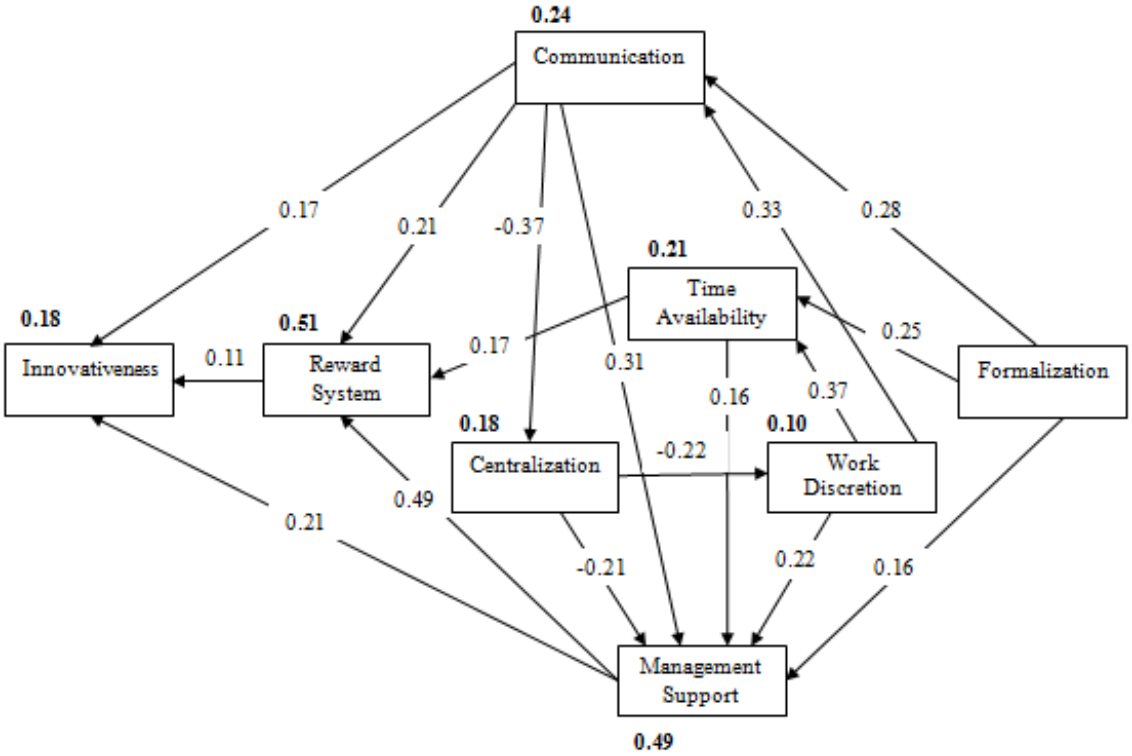

Figure 4 Path analysis model for organization culture.

As mentioned above centralization is negatively correlated to innovativeness as well as all the other factors. Path analysis model in Figure 4 also shows that the more centralized an organization is, the less opportunity the employees have for exercising initiative and hence, blocking the way to new approaches and innovation. It has a similar effect through decreased top management support for new ideas, projects and risk taking behaviour of the employees. Communication appears to act as an antidote to centralization.

6. Further comments

Two of the more important constructs, the intellectual capital and organization culture have been analyzed above in detail. Different policies can be derived from these analyses. For example, human resource possessed by a manufacturing firm is found to be the most effective innovation determinant on innovativeness. One of the policies in line with this would be the need for emphasis on human resources. The recruitment process should be taken very seriously for attracting young innovative talent. The working environment should be conducive for innovation and growth. This is not only a must for recruitment purposes but also for keeping the talent within the firm.

Rather than trying to enumerate such policies as a list we have decided to conclude with remarks concerning the need for an innovation strategy acting as a framework for all such individual policies. Innovativeness in a firm should not be expected to occur by chance through some random events but should be cultivated through an innovation strategy with a 3-5 years rolling time horizon consisting of several time phased and possibly interacting projects. These projects should be planned, staffed, directed, and controlled with allocated budgets and sponsored by top management. Like any other management endeavour innovation strategy together with its project portfolio should be assessed through well defined and transparent performance criteria – input and output innovation metrics [19].

Acknowledgement

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