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An Approach to Measure Innovativeness of a Firm

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Abstract:
Recent studies have shed light on different firm capabilities that contribute to a firm's innovativeness. This study proposes a new framework that is based on the analytic hierarchy process (AHP) for measuring firm-level innovativeness. On the basis of an in-depth literature review and survey responses from industry experts, we identify firm-level capabilities and indicators that are crucial to innovativeness. The proposed framework is tested using data from three sectors such as consumer products firm, industrial systems firm and power systems firm of Indian Electrical Engineering Company. Results confirm that innovativeness of sectors is related to the firm's R&D, manufacturing, marketing, and organizational capabilities.

Keywords: *Innovativeness, R&D, marketing, manufacturing Performance, organizational, Indicators, capability, AHP*

1. Introduction

An innovative firm is one "that adopts innovations" (Utterback 1974; Daft 1982; Attewell 1992). In other words, the more innovations a firm adopts, the more innovative it is considered. Rogers (2003) defined innovativeness as "the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than any other member of the system." Innovativeness has been identified as a key factor influencing a firm's overall performance and growth (Hurley & Hult 1998). Consequently, the innovativeness of firms and the factors that contribute to it have been widely studied in the past few years.

Organizational management (Avlonitits, Kouremenos, and Tzokas, 1994), marketing (Erdil, 2004), manufacturing (Fell, Hansen, and Becker, 2002), research and development (Hogedroom and Cloodt, 2003), and the interactions between these units have been reported to contribute to a firm's overall innovativeness. Avlonitis, Kouremenos, and Tzokas (1994) discussed the role of organizational capability and industrial capability in measuring firm innovativeness. Similarly, Hogedroom and Cloodt (2003) discussed the impact of R&D, intellectual property (IP), and new products on firm performance. Tsai, Chuang, and Hsieh (2008) measured, firm innovativeness using market, organizational, and R&D capabilities. Typically, the marketing division of a company is responsible for identifying the needs and problems of the consumers, which ultimately translate into inputs for the R&D team. The R&D division uses these inputs to devise products that are capable of addressing the consumers' demands. Thus, the R&D and marketing divisions are directly linked to a company's development of innovations/new products (Artz, Norman, & Hatfield, 2003; Tecu, 2011, Erdil, 2004). Similarly, a marketing unit can also help the R&D division develop products that are revolutionary, such as a new technology with huge commercial prospects (Tecu, 2011).

Usually, a manufacturing unit does not directly influence the innovation process. However, it can contribute towards overall growth through process improvements and collaborations with the R&D division. Insights and feedbacks from the manufacturing division can help the R&D division optimize materials, costs, processes, machinery, etc. Such changes can reduce the overall cost of the product or improve the efficiency of other components. Finally, organizational capability supports all the units of the organization, and thus contributes to firm innovativeness (Knight and Cavusgil, 2004).

Prior studies on firm innovativeness have focused on the impact of individual factors. No study has determined firm innovativeness by jointly studying R&D, marketing, manufacturing, and organizational capabilities and their interactions. The objective of this paper is to develop an innovation measurement tool that is based on the analytical hierarchy process (AHP). To this end, we identify different indicators of innovativeness by reviewing existing literature and then clustering them into categories of organizational capability. We also propose a new framework for measuring innovativeness by examining a range of innovations adopted by firms belonging to different industries and by drawing on commonly used methods of innovation measurement. The model proposed in this study can be used by firms to develop an innovativeness index that identifies key capabilities influencing the firms' innovation success. This information can then be strategically applied to maximize the firms' innovation success.

2. Literature Review

Previous studies have used different approaches to identify indicators of innovativeness. Here, we review some of the approaches, examine their strengths and drawbacks, and select the capabilities and indicators that are relevant to firm-level innovativeness.

2.1. Time of Technology Adoption

Rogers (1962) used the time of adoption as a factor and accordingly divided individuals or firms into adopter groups. However, one of the most significant drawbacks of this method is that the exact time of adoption of an innovation cannot be easily determined. Robertson (1971) proposed the cross-sectional method in which innovativeness is determined by measuring the number of new products owned or used by a firm at any given point of time. Each of these products is usually at a different stage in the diffusion process. Robertson assumed that an innovative firm will use the newly developed products at any given point of time. This method was an improvement on Rogers' (1962) method as it considered more than one innovation to measure innovativeness and completely eliminated the need for time of adoption.

Avlonitis, Kouremenos, and Tzokas (1994) defined innovativeness as a multidimensional concept and attempted to measure it by examining a cross-section of innovations adopted by organizations across multiple industries. Arguing that the methods used by Avlonitis, Kouremenos, and Tzokas (1994) and Rogers (2003) did not measure the same construct, Fell, Henson, and Becker (2003) developed a composite method to measure innovativeness, which was a hybrid of the two methods. The composite method was based on product categories and accounted for the time of adoption. Carayannis and Provance (2008) also developed a composite innovativeness index composed of three indicators: input, process, and output-oriented measures. These measures were derived from the 3P framework, which posited that innovation stems from three critical firm-level factors: posture, propensity, and performance.

Most of the empirical studies on innovative activity are based on one or very few indicators (Hollenstein, 1996). A robust measurement approach should consider a composite score of a firm's innovativeness, derived from a range of technical and market indicators that capture the complexity of the innovation process.

2.2. Self-Evaluation

The self-evaluation method for measuring innovativeness was proposed by various researchers (Carter & Williams, 1959; Wallach, 1983; Wind and Mahajan, 1997; Gebert, Boerner, & Lanwehr, 2003; Crespell, Knowles, & Hansen, 2006). In this method, the dimensions of innovativeness identified by the firm are rated on an interval scale by firm employees. Carter and Williams (1959) used the self-evaluation method to assess the technical progressiveness of firms. Wind and Mahajan (1997) used it for determining the best practices in new product development (NPD). Deshpande and Farley (2004) used self-evaluation to study the innovativeness of firms operating in business-to-business markets.

2.3. Intellectual Property (IP)

Innovativeness has also been measured on the basis of a firm's intellectual property (Hall, Griliches, & Hausman, 1986; Basberg, 1987; Artz, Norman, & Hatfield, 2003) and funding available for or allocated to R&D. Hollenstein (1996) relied on IP to develop a composite measure of a firm's innovativeness by means of a factor analysis.

2.4. Analytic Hierarchy Process (AHP)

The analytic hierarchy process (AHP) was developed to solve complex multi-criteria decision problems (Saaty, 1980). Capable of handling both qualitative and quantitative multi-criteria problems, AHP integrates different measures into a single overall score for ranking decision alternatives. Vargas (1990) explained that AHP is based on the premise that to make decisions, experience and knowledge are as valuable as the data used, if not more. AHP applications are typically carried out in two phases: hierarchy design and evaluation. Designing of hierarchies requires experience and knowledge of the problem area, and the evaluation phase is based on the concept of paired comparisons (Vargas, 1990). In the past, AHP has been applied to a variety of decision-problem situations such as car purchase (Byun, 2001), project selection (Kamal, 2001), vendor selection (Tam and Tummala, 2001), IS project selection (Muralidar & Santhanam, 1990; Schniedejans & Wilson, 1991), software selection (Kim and Yoon, 1992; Mamaghani, 2002), evaluation of fishery management options in Hawaii (Leunga, Murarka, Nakamoto, & Pooley, 1998; Ngai and Chan, 2005), and patent valuation (Chiu and Chen, 2007). Recently, Tsai et al. (2008) used AHP to measure organizational innovativeness in a high-tech industry, where technical and administrative innovation served as the indicators for R&D ranking. The advantages of AHP over other multi-criteria, methods are its flexibility, intuitive appeal to the decision makers, and its ability to check for inconsistencies. AHP helps capture both subjective and objective evaluation measures and reduces bias in decision making.

Organizational learning capability, managerial capability, R&D investment intensity, and integration of R&D and marketing have also been used to measure innovativeness (Ali, Halit, Bymeb, & Aren, 2007; Rocha, Vhristensen, & Paim, 1990; Lefebvre, Lefebvre, & Tablot, 2000; Walsh, 2002; Ho, Keh, & Ong, 2005; Chen, Chen, Li, & Wei, 2007; and Hernandez, 2006). Although a number of indicators and metrics have been used to measure innovativeness, to our knowledge, no study has considered a composite measure that involves R&D, manufacturing, and marketing functions. Further, most researchers have used either qualitative or quantitative measures.

In this study, we hypothesize that a firm will be more innovative when an innovation developed by an R&D division with high R&D capability is manufactured by a manufacturing unit (with high capability) and marketed by a marketing unit (with high capability). This process will generate more profit and make the innovation more successful.

Accordingly, we have identified qualitative and quantitative indicators that capture the innovativeness of four critical firm capabilities—R&D, manufacturing, marketing, and organizational. Table 1 lists the indicators of innovativeness by capability. Note that R&D and organizational capabilities have been subdivided to reduce the computational complexity and facilitate better understanding.

Capabilities	Indicators	Metrics	Citation
R&D Capability (R&D & knowledge management)	1) R&D intensity	(i) % of researchers to overall employees	Wang, Lu, & Chen, (2007)
		(ii) S&T Personnel, technical intensity, university graduate	Hollenstein (1996), Wang, Lu, & Chen, (2007)
		(iii) Technology trends in the patents filed	Abraham and Moitra,(2001)
		(iv) individual innovativeness	Hollenstein (1996), Wang, Lu, & Chen, (2007)
		(v) Efficiency of development/activities	Hollenstein (1996),
	2) Intellectual knowledge portfolio	(i) Number of patents & self-generated R&D products	Wang, Lu, & Chen, (2007) ; Carayannis, & Provance, (2008), Hollenstein (1996), Hall, Griliches, &. Hausman (1986), Haner (2002)
		(ii) Number of innovation counts, new product announcements	Hollenstein (1996)
		(iii) Science linkage (number of references to the scientific paper)	Hagedoom and Cloodt (2003)
	3) Success rate of R&D product	(i) Success rate of R&D product, share in sales of innovative products	Wang, Lu, & Chen, (2007)
		(ii) License	Wang, Lu, & Chen, (2007)
		(iii) acceptance rate throughout the workforce	Haner(2000)
	4) R&D expenditure	(i) R&D & education expenditure	Blomqvist, Harkink, Drongelen, Kuittinen, & Ojanen, (2004)' Hagedoom and Cloodt (2003) ,
		(ii) R&D activity	Damanpour, Szabat, & Evan (1989)
	5) Role of leadership innovation & supports	(i) equipment, facilities, innovation leadership	Avlonitis, Kouremenos, & Tzokas (1994), Damanpour, Szabat, & Evan (1989)
		(ii) R&D commitment	Adams (2006)
	6) Novelty & uniqueness of innovation	(i) product innovativeness, novelty of innovations of substantially improved product	Avlonitis, Kouremenos, & Tzokas (1994) , Hall, Griliches, &. Hausman (1986)
		(ii) Type of novelty	Avlonitis, Kouremenos, & Tzokas (1994)
	7) Contribution of skills & expertise	(i) people in terms of propensity to innovate and skills, experience and education	Blomqvist, Harkink, Drongelen, Kuittinen, & Ojanen, (2004)'
		(ii) R&D efforts & closeness to basic research	Jacques & Mohnen (2001)

R&D Capability (Innovation decision & project management)	1)Internal & external Knowledge sharing ability	(i) intensity of collaboration with other firms or R&D centers and networking	Wang, Lu, & Chen, (2007), Blomqvist, Harkink, Drongelen, Kuittinen, & Ojanen, (2004), Damanpour, Szabat, & Evan (1989),
		(ii) Newness of innovation, new to the firm, new to the industry	Carayannis, & Provance, (2008)
	2) Innovation strategies & initiatives	(i) forecasting & evaluating technological innovation & entrepreneurial innovation capabilities)	Wang, Lu, & Chen, (2007), Hollenstein (1996)
		(ii) innovativeness of core machinery, Innovation strategy, policy and long term Plan.	Avlonitis, Kouremenos, & Tzokas (1994) , Blomqvist, Harkink, Drongelen, Kuittinen, & Ojanen, (2004),
	3) Project management (control & monitoring)	(i) Process (design of innovation management, idea evaluation, concept test, profitability analysis, innovation strategy, construction/development, ex-post analysis, project management & controlling & project management employed and project controlling employed	Carayannis, & Provance, (2008), Haner (2002)
		(ii) High level of management support for the project	Juranne (2006)
	4) Innovativeness compatibility	(i) benchmarking innovation capacity	Avlonitis, Kouremenos, & Tzokas (1994) , Hall, Griliches, &. Hausman (1986)
		(ii) Innovations design, process & product innovation	Avlonitis, Kouremenos, & Tzokas (1994)
		(iii) degree of innovativeness, type of innovation & newness to the innovation	Avlonitis, Kouremenos, & Tzokas (1994)
		(iv) compatibility & degree of complexity	Haner (2002)
		(v) Speed of generation of innovation & rate of adoption of innovation	Damanpour, Szabat, & Evan (1989)
		(vi) effectiveness & reliability & amount of innovations	Haner (2006)
	5) Technology trends assessment	(i) Technology pattern	Abraham, & Moitra (2000)
		(ii) Technology management	Abraham, & Moitra (2000)
	6) Rate of introduction of new product/ service per year	(i) rate of innovation of new operational processes & rate of introduction of new products & services	Hagedoom and Cloodt (2003)
		(ii) process/product innovation of introduction of new products & services	Hagedoom and Cloodt (2003)
Marketing capability	1) Market characteristics	(i) Market share (shares in sales of innovative products & innovative sales), export %, market penetration	Wang, Lu, & Chen, (2007), Blomqvist, Harkink, Drongelen, Kuittinen, & Ojanen, (2004),
		(ii) Economic demand	Blomqvist, Harkink, Drongelen, Kuittinen, & Ojanen, (2004),
		(iii) customer intimacy	Haner (2002)
	2) Product promotion & pricing strategy	(i) changes in product design or packaging, product placement, product promotion or pricing, marketing & publicity	Damanpour, Szabat, & Evan (1989)
		(ii) market focused strategy, well planned product & service development process, length of time between the conception of a new product & its introduction into the market place	Blomqvist, Harkink, Drongelen, Kuittinen, & Ojanen, (2004), Damanpour, Szabat, & Evan (1989)

		(iii) distribution of commercial products	Hall, Griliches, &. Hausman (1986)
	3) Degree of market competition	(i) Degree of new product competitiveness, presence of related firms (competitors) , innovations of other businesses in the same industry (market competitors) & suppliers of materials	Wang, Lu, & Chen, (2007)
	4) Commercialization success rate	(i) Sales share of world novelties (%), Sales share of highly improved or new products (%) , Sales share of products in the introduction stage of the life cycle (%), Sales share of products in the introduction and growth stage of the life cycle (%)	Hollenstein (1996), Carayannis, & Provance, (2008), Wang, Lu, & Chen, (2007), Damanpour, Szabat, & Evan (1989)
		(ii) increase in customer loyalty per year, cost value to customer	Haner (2002)
Manufacturing Capability	1) Product cycle time	(i) product cycle time	Wang, Lu, & Chen, (2007)
	2) Product quality level	(i) product quality level	Wang, Lu, & Chen, (2007)
	3) Production staff quality level	(i) production staff quality level, staffing level effectiveness in product development	Wang, Lu, & Chen, (2007), Haner (2002) .
	4) Advanced manufacturing technology	(i) Advanced manufacturing technology, manufacturing technology & technical competency, new functional solution based on existing product, technical features of product innovations, technical features of process innovations such as new production technique, automation	Wang, Lu, & Chen, (2007), Hall, Griliches, &. Hausman (1986), Hollenstein (1996)
		(ii) efficiency & productivity improvement	Haner (2002)
	5) Rate of adoption of new technology to support innovation	(i) use of new materials or intermediate products, fundamentally new production system	Hollenstein (1996)
		(ii) components & equipments & effective use of outside technology	Haner (2002)
	6) Technology success rate	(i) Technology success rate & Commercialization	Wang, Lu, & Chen, (2007)
Organizational Capability (Capital capability)	1) Return on investment	(i) Return on investment, Profit share of innovation, Return on investment & project net present value	Wang, Lu and Chen, (2007), Haner (2002) Carayannis, & Provance, (2008) , Hall, Griliches, &. Hausman (1986)
	2) Capital intensity &allocation	(i) Capital intensity & allocation, Follow-up investment	Wang, Lu and Chen, (2007), Hollenstein (1996),
		(ii) Technological incorporated into the capital & not incorporated into the capital	Haner (2002)
		(iii) investment for commercialization of new innovations	Hall, Griliches, &. Hausman (1986)
	3) Fundraising ability	(i) Innovation cooperation funding	Wang, Lu and Chen, (2007), Hall, Griliches, &. Hausman (1986)
	4) Turnover generated by the innovative products	(i) Turnover generated with innovative products	Haner (2002)
	5) Payback period	(i) Payback period	Wang, Lu, & Chen, (2007), Carayannis, & Provance, (2008), Haner (2002)

Organizational Capability (Organization culture & structure)	1) Culture of the organization	(i) Culture of organization	Haner (2002)
	2) Structure of organization	(i) Structure of organization & Organization modernization	Haner (2002),

Table 1: Capabilities and indicators determined from the literature review

Figure 1 presents the proposed AHP-based framework for measuring innovativeness. Each component of innovativeness was measured using the relevant indicators. The internal strength of the firm was measured on the basis of capital capability, organizational structure, and culture indicators.

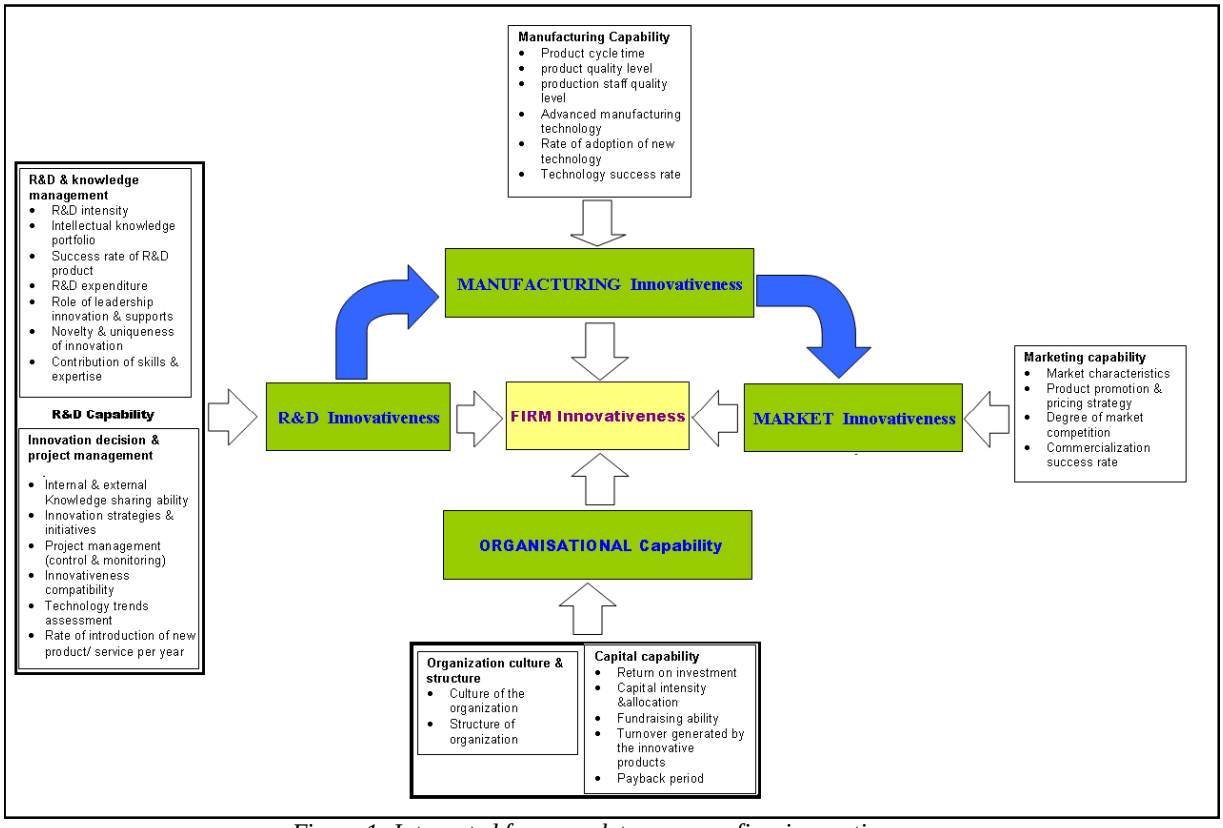

Figure 1: Integrated framework to measure firm innovativeness

3. Methodology

Figure 2 illustrates the methodology used to identify the indicators of innovativeness. We identified appropriate indicators for the four different capabilities with the help of industry experts and through an in-depth review of the literature. For example, for the marketing capability, we identified the following five indicators: market characteristics, product promotion, pricing strategy, a degree of market competition, and commercialization success rate. To understand the effects of interactions between different organizational capabilities, we surveyed some of the most experienced employees from the R&D, marketing, and manufacturing divisions of three electrical companies in India. The responses highlighted how constant interactions between the divisions of a firm are beneficial for the overall growth.

Next, we tested the proposed framework by surveying employees from three different sectors of a Indian engineering company operating in the field of consumer products (CP), industrial systems (IS) and power systems (PS) with R&D and manufacturing facilities in India. Each sector includes group of manufacturing companies having R&D, and Marketing base. Firm A (IS) had 90 scientists in its R&D department, a moderate number of patents, and sufficient R&D funding. Firm B (PS) had 180 scientists, a good number of patents to its credit, and the highest R&D investment of the three firms. Firm C (CP) had 50 scientists, few patents, and limited funding for R&D activities. Each firm A, B and C includes group of manufacturing units, R&D and marketing region.

A total of 225 experts—marketing professionals, technology heads, and production heads—were surveyed (in person and via e-mail) with help of a questionnaire. Of these, 154 experts (68 percent response rate) returned completed the questionnaires. They

were asked to the rank the capabilities listed in the questionnaire in order of importance. It must be noted that the R&D capability was further divided into (i) R&D and knowledge management and (ii) innovation decision and project management. Similarly, organization capability was broken into (i) capital capability and (ii) organization culture and structure. The experts from the capability-specific domains were also asked to rate the indicators on a scale of 1–5, with 1 indicating "strongly disagree" and 5 indicating "strongly agree." They had to weight each capability according to its perceived importance in their organization.

Mean ratings of each indicator were calculated to arrive at an overall rating for the capability; the mean ratings reflected the importance of each indicator in the overall capability rating. The questionnaire also sought information about the quantitative and qualitative aspects of each capability, which were used to calculate performance variables. These performance variables (P1 for firm A, P2 for firm B, and P3 for firm C) were calculated on the basis of expert opinions and firm-specific information such as number of patent filings, number of projects in the pipeline, rate of leveraging of innovation, etc. The values were used in the measurement of innovativeness.

We calculated the weightage of each capability vis-à-vis the others after the respondents had weighted them. Since innovation decision capability had only half the importance of R&D capability, it was rated accordingly. We used the peer method to assign these comparative ratings or scores. We multiplied all the ratings for each capability to find the geometric mean value (GM1). GM1 was used to calculate the capability weightage (CW).

After estimating the capability weightage, we calculated the indicator weightage (IW) by a peer analysis method, which involves rating a particular indicator against all other indicators as per importance. We multiplied all the ratings for each indicator for finding the geometric mean value (GM2). This was used to calculate IW. Finally, we calculated performance variables (PV) of indicators based on the ratings provided by the respondents.

We multiplied both the values (i.e., CW and IW) to arrive at the final average weightage (w) of each indicator under a given capability. This final average weightage (w) was later multiplied with the indicator performance value (P) of each firm for determining the innovativeness value (IV) of each indicator, capability, and firm.

The AHP method is used in decision-making situations that involve multiple objectives. Since this study uses a multi-dimensional approach to evaluate a firm's innovativeness, we chose the AHP method for analysis. AHP is computationally simple and offers accurate results. Other methods discussed in prior art do not facilitate ranking of the firms; they only provide qualitative results. Our process for firm innovativeness measurement involved the following steps:

i. Selecting innovativeness capability and indicators

- Classifying and grouping criteria into their corresponding indicators
- Preparing a hierarchy tree of indicators and their corresponding parameters

ii. Drafting the questionnaire
iii. Collecting data
iv. Applying AHP
v. Calculation and analysis

- Calculating the weightage of each capability and indicator
- Calculating the performance variable for each of the sample firms
- Multiplying the performance variable of each indicator with its corresponding weightage
- Calculating the simple additive weight (SAW)
- Ranking the firms

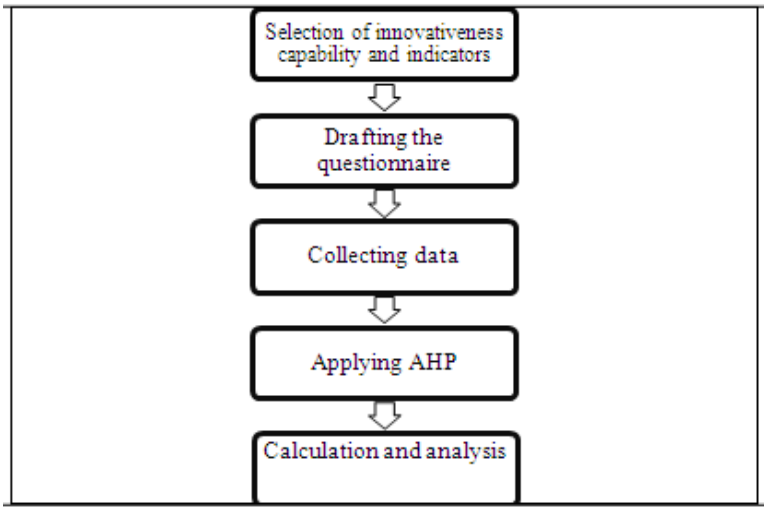

Figure 2 : Process flowchart for measuring firm innovativeness

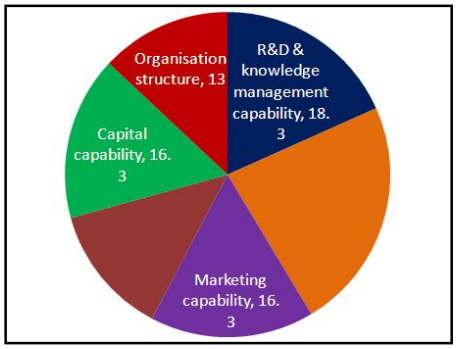

Figure 3: Importance level of firm Capabilities

4. Analysis and Discussion

The measures of innovativeness considered in this study have been derived from a review of relevant literature and survey responses from industry experts. We used AHP (1) to determine the weightage of the indicators under each capability and then ranked the firms A, B and C by the SAW method. A final appraisal score Ai for each i^{th} firm was computed by multiplying the j^{th} indicator's importance weight wj by the 5-point scale of the i^{th} firm on the j^{th} indicator. The preference was then ordered according to the score. The firm with the highest score was chosen as the best. For m attributes and n firm, when an expert assigned a set of importance weights to attributes, the most preferred firm (A*) is selected such that

$$A^* = \left\{ A_i \left| \max_i \sum_{j=1}^{m} w_j x_{ij} \right. \right\}, \quad i = 1, 2, \ldots, n; \; 1 \le x_{ij} \le 5 \qquad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where $x_{i\,j}$ is the rating of the j^{th} attribute on the i^{th} firm. The $x_{i\,j}$ rating scale [1–5] is defined in the following way: 1 strongly disagree, 2 disagree, 3 slightly agree, 4 agree, and 5 strongly agree. The resulting weights are shown in Table 2.

Capabilities Level		**Indicators level**	
Capability Weightage value (CW)		Final Average Weightage (w) value (IW)	
R&D Capability (R&D & knowledge management capability)	0.183	R&D intensity	0.0203
		Success rate of R&D products	0.0302
		Intellectual knowledge management	0.0140
		Role of leadership innovation	0.0115
		Skills & expertise	0.0547
		novelty & uniqueness of Innovation	0.0315
		R&D expenditure	0.0212
R&D Capability (Innovation decision capability & project management)	0.231	Assessment on Technology Trends	0.02078
		Innovativeness compatibility	0.04239
		Internal & external knowledge sharing ability	0.03530
		Innovation strategies & initiatives	0.03962
		Rate of new introduction of new product/services per year	0.07060
		Project management & controlling	0.02224
Marketing capability	0.163	Market characteristics	0.03382
		Product Promotion & pricing strategy	0.02011
		Degree of market competition	0.04452
		Commercialization success rate	0.06484
Manufacturing capability	0.130	Advanced manufacturing capability	0.02160
		Product quality level	0.02160
		Production staff quality level	0.02160
		Rate of adoption of new technology to support innovation	0.04320
		Product cycle time	0.02160
Organisation Capability (Capital capability)	0.163	Capital allocation & fundraising ability	0.03266
		Return on investment & Payback period	0.06532
		Turnover generated by the innovative product	0.06532
Organisation Capability (Organisation structure & culture)	0.130	structure & culture	0.12960

Table 2 : Weights of firm innovativeness

The weight or performance values for each indicator, capability, and firm (A, B, and C) are shown in Tables 3, 4, and 5 respectively.

Indicators	**Final Average Weightage (w) value (IW)**	**Performance variable (PV)**			**Innovativeness value (IV)**		
		Firm A IS (P1)	Firm B PS (P2)	Firm C CP (P3)	Firm A IS (IW*P1)	Firm B PS (IW*P2)	Firm C CP (IW*P3)
R&D intensity	0.0203	3.167	2.625	2.667	0.064	0.053	0.054
Success rate of R&D products	0.0302	3.167	2.813	2.047	0.096	0.085	0.062
Intellectual knowledge management	0.0140	2.417	2.854	2.500	0.034	0.040	0.035
Role of leadership innovation	0.0115	3.000	3.000	2.813	0.034	0.034	0.032
Skills & expertise	0.0547	2.833	2.917	2.987	0.155	0.159	0.163
novelty & uniqueness of Innovation	0.0315	2.500	2.417	2.413	0.079	0.076	0.076
R&D expenditure	0.0212	2.083	1.688	2.140	0.044	0.036	0.045
Assessment on Technology Trends	0.02078	2.667	2.563	2.620	0.055	0.053	0.054
Innovativeness compatibility	0.04239	3.083	2.458	2.547	0.131	0.104	0.108
Internal & external knowledge sharing ability	0.03530	2.750	2.667	2.287	0.097	0.094	0.081
Innovation strategies & initiatives	0.03962	2.833	2.479	2.427	0.112	0.098	0.096
Rate of new introduction of new product/services per year	0.07060	3.083	2.583	2.587	0.218	0.182	0.183
Project management & controlling	0.02224	2.500	2.396	2.447	0.056	0.053	0.054
Market characteristics	0.03382	2.750	2.417	3.140	0.093	0.082	0.106
Product Promotion & pricing strategy	0.02011	2.917	2.729	3.060	0.059	0.055	0.062
Degree of market competition	0.04452	3.000	2.938	3.400	0.134	0.131	0.151
Commercialization success rate	0.06484	3.083	2.688	2.827	0.200	0.174	0.183
Advanced manufacturing capability	0.02160	2.667	2.771	2.333	0.058	0.060	0.050
Product quality level	0.02160	3.500	2.896	3.367	0.076	0.063	0.073
Production staff quality level	0.02160	3.167	2.438	2.967	0.068	0.053	0.064
Rate of adoption of new technology to support innovation	0.04320	3.250	2.333	2.487	0.140	0.101	0.107
Product cycle time	0.02160	3.167	2.563	2.580	0.068	0.055	0.056
Capital allocation & fundraising ability	0.03266	2.667	2.458	2.527	0.087	0.080	0.083
Return on investment & Playback period	0.06532	2.417	2.583	2.607	0.158	0.169	0.170
Turnover generated by the innovative product	0.06532	2.667	2.875	2.613	0.174	0.188	0.171
structure & culture	0.12960	3.000	2.75	3.073	0.389	0.356	0.398

Table 3: Innovativeness value of each indicators with respect to firm A, B and C

Capability Level		Performance Variable			Innovativeness Value (IV)		
	Weightage (CW)	Firm A IS	Firm B PS	Firm C CP	Firm A IS (IV)	Firm B PS (IV)	Firm C CP (IV)
R&D & knowledge management capability	0.183	2.74	2.62	2.51	0.502	0.479	0.460
Innovation decision capability & project management	0.231	2.82	2.52	2.49	0.651	0.583	0.574
Marketing capability	0.163	2.94	2.69	3.11	0.480	0.440	0.507
Manufacturing capability	0.130	3.15	2.70	2.75	0.408	0.350	0.356
Capital capability	0.163	2.58	2.64	2.58	0.422	0.431	0.422
Organization structure	0.130	3.00	2.75	3.07	0.389	0.356	0.398

Table 4: Innovativeness value of each capability

Alternatives	SAW value (Ai)	Rank
Firm A – IS Industrial Systems	2.851	1
Firm B – PS Power Systems	2.639	3
Firm C - CP Consumer Product	2.717	2

Table 5: Performance value of each alternative and the ranking results

The performance value (P) obtained for each indicator was multiplied by its respective weightage value to arrive at the innovativeness value for each firm. The sum of all these was considered the final SAW value for each firm, which in turn determined the rank of the firm (Table 3).

Table 2 shows that innovation decision capability and project management have the highest degree of importance (0.231), followed by R&D and knowledge management capability (0.183); marketing capability and Capital capability (both 0.163); manufacturing capability (0.130); and organization structure and culture (0.130). These ratings indicate that innovative decision capability and project management skill are essential to a firm's innovativeness.

Of the indicators specific to the innovative decision capability and project management, the rate of introduction of new product/services per year and Innovativeness, compatibility are most relevant to a firm's innovativeness, with scores of 0.07060 and 0.04239, respectively. Skills and expertise (0.0547) and novelty and uniqueness (0.0315) are the indicators with the highest relative importance under the R&D and knowledge management capability.

The indicator with the highest rating under the manufacturing capability is the rate of adoption of new technology to support innovation, with a score 0.0432. Within capital capability, return on investment and payback period as well as turnover generated by the product is equally important indicators, with a rating of 0.06532. The scores of firms A, B and C are shown in Table 3. Firm A has the highest scores in many capabilities such as R&D (R&D & knowledge management capability, innovative decision capability and project management), marketing, manufacturing, and organizational (capital capabilities).

The innovativeness performance value of firm A is greater than that of firms B and C (see figure 4 and Table 5). The R&D capability (R&D & knowledge management) of firm A has contributed majorly toward its innovativeness. Firm C is ranked second. Again, the chief contributor to the firm's innovativeness is its R&D capability (innovative decision & project management). Firm B is ranked third, having innovative decision & project management as the highest contributor to its innovativeness score.

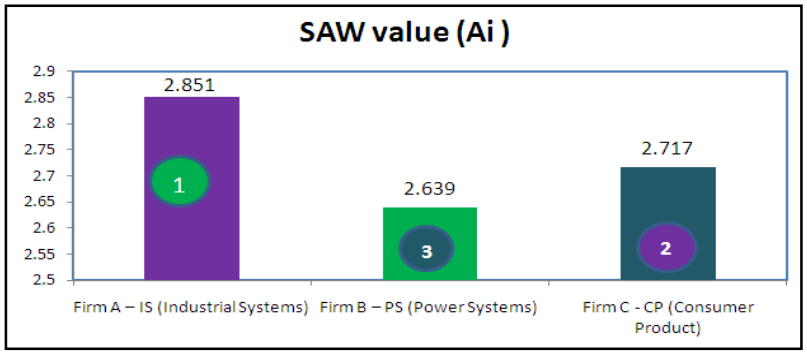

Figure 4: Performance value of each alternative and the ranking results

These results confirm that no single capability or indicator is responsible for product success. Positive and high levels of contribution from all the capabilities and indicators are essential. Similarly, a product cannot succeed on account of the efforts of one unit; all the units need to contribute to its success. R&D, manufacturing, and marketing units enable an organization to be more innovative. Factors that enhance Firm A's innovativeness is the result of its global presence, high technology background, and its global leader status in the market. The employee strength of the R&D division as well as the quality of infrastructure, technology, production, and marketing has enabled the firm to be more innovative. Inputs, interactions, and collaborations between the various units have contributed to firm A's overall success.

5. Consclusions and Recommendations

Innovativeness measurement has been attracting a lot of attention in the recent past with innovation playing a key role in organizational growth strategies. As part of this study, we reviewed existing literature on innovativeness measurement. The review highlighted the need for an integrated framework for measuring firm innovativeness. Accordingly, we developed a framework that considers multiple indicators and metrics. With the help of an AHP-based approach, we have demonstrated the contribution of each indicator toward firm innovativeness. Our test results show that all four capabilities—R&D, manufacturing, marketing, and organizational—are important for ensuring innovativeness.

While the proposed framework is useful for measuring firm-level innovativeness, it cannot be applied to firms that lack dedicated R&D centers, manufacturing units, or marketing departments. Future studies should focus on the innovativeness measurement for such firms and explore the capabilities and indicators that are relevant to them. The use of other advanced and accurate methods for measuring innovativeness such as fuzzy logic may also be explored.

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