Proceedings of GLOGIFT 12
July 30 – August 1, 2012
University of Vienna, Austria
pp. 501-510

Impact of Technological Capability and Competency in Managing Strategic Flexibility in Indian Manufacturing Industry - An Empirical Study

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Abstract

Manufacturing industry has experienced a very high degree of change in the recent years, involving changes in process technology, customer expectations, supplier attitudes, competitive behavior and many more aspects. These parameters have jointly contributed to greater uncertainty and volatility of enterprise management processes. The organizations need to be flexible enough to absorb these fluctuations. The objective of this paper is to explore the impact of Technological Competences and Capabilities on strategic flexibility dimensions in manufacturing organizations of India. The study involved 102 large and medium scale manufacturing organizations across the country. A stepwise regression technique was used and the research findings revealed that organizations emphasizing on updating and improving their technology have high manufacturing and new product flexibility

Introduction

The basic competitive priorities generally considered by academician and professionals are quality, delivery, price and flexibility. However, the past decade has witnessed an increased interest in flexibility, which bestows on a firm the ability to respond promptly to market opportunities and changing technologies and most likely to continue with ever increasing changes in the marketplace. The investigation of strategic choice of aligning flexibility development with the external environment that manufacturing manager's face, considering uncertainties in demand, material supply, competition and new product technology, indicates the need of matching the manufacturing flexibility with environmental uncertainty to ensure profit and sales performance (Chang *et al.*, 2002). Flexibility has been heralded as a major competitive weapon for manufacturing organizations operating in increasingly uncertain environments and turbulent markets. It has been considered in the literature that manufacturing flexibility has the capability to provide organizations with the ability to change levels of production rapidly, to develop new products more quickly and more frequently, and to respond more rapidly to competitive threats.

Today, most organizations share access to the same manufacturing processes, systems, etc. The competition is therefore no longer based on manufacturing technology as such, but rather on how well the organizations manage the technology relative to its customers (Oberoi *et al*, 2008). Past research on manufacturing flexibilities has tended to focus on newer technologies as a means for achieving manufacturing flexibility goals. A number of researchers have concluded

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that there is a positive correlation between newer technologies and flexibility (Singh *et al.*, 1996; Dangayach and Deshmukh, 2004; Narasimhan *et al.*, 2004).

The purpose of this work is to understand and explicate the interaction between Advanced manufacturing technology (AMT), Infrastructural flexibility (IF) and Technological capabilities (TC) with New product flexibility (NPF) and Manufacturing flexibility (MFF), and assess their relative impact on different flexibilities.. It is hypothesized that AMT, IF and TC will influence NPF and MFF positively. The focus of the study is on large- and medium-scale manufacturing enterprises of North India. As per prevailing definition, a large-scale manufacturing enterprise in India is defined as an industrial undertaking in which the investment in fixed assets in plants and machinery, whether held on ownership term or lease or on hire/purchase, does not exceed Rs1,000 million. For medium-scale enterprises, the range is Rs10–100 million in fixed assets in plants and machinery.

Literature Review

An exhaustive literature survey has been carried out on flexibility in manufacturing organizations and advanced manufacturing technologies being used in manufacturing industry.

Flexibility in Manufacturing Organizations and Its Dimensions

The concept of flexibility in an organizational context refers to the ability to precipitate intentional changes, to continuously respond to unanticipated changes, and to adjust to the unexpected consequences of predictable changes (Bahrami, 1992). At a broad level, flexibility can be understood as an absorber of environmental uncertainty and variability (Gerwin, 1993; De Toni and Tonchia, 1998). Flexibility is regarded as a positive feature since it contributes to the organization's ability to absorb or even benefit from variations in its environment. Upton's (1994) oft-quoted definition is "flexibility is the ability to change or react with little penalty in time, effort, cost or performance". Upton (1995) discusses different strategies that an organization may employ to become flexible and suggests that flexibility is both a multidimensional and multilevel attribute. Upton's arguments suggest that flexibility is enacted as a response to different classes of problems and that there are usually multiple responses to the same set of problems. Sushil (1997) advocates the concept of systemic flexibility, which is defined as the exercise of free will or freedom of choice on the continuum to synthesize the dynamic interplay of thesis and antithesis in an interactive manner, capturing the ambiguity in the systems, and expanding the continuum with minimum time and effort.. Zhang *et al.* (2006) perceives flexibility as the organization's ability to meet an increasing variety of customer expectations without excessive costs, time, organizational disruptions, or performance losses.

Boppana *et al.* (2007) captured the complexities from the flexibilities and fit them into entity-relationship model and also gives an idea of how the developed individual models can be used to evaluate the flexibility options in a manufacturing system. Hitt *et al.* (1998) define flexibility as the capability of company to proact or respond quickly to changing competitive conditions and thereby develop and/or maintain competitive advantage. Sethi and Sethi (1990) summarized that flexibility is a complex, multidimensional and hard-to–capture concept. Koste and Malhotra (1999) define ten dimensions of flexibility and introduce a hierarchy of flexibility dimensions ranging from individual resource, to shop floor, plant, functional and business unit.

Narasimhan and Das (1999) suggested taxonomy of flexibility as operational flexibilities, tactical flexibilities and strategic flexibilities (Table 1)

Flexibility has been discussed in wide variety of areas like strategic management, economics, organization theory and marketing literature. Different authors have discussed different definitions

Table 1: Taxonomy of Flexibility

Operational Flexibilities (Machine/Shop level)	Equipment flexibility	The ability of a machine to switch among different flexibilities types of operations without prohibitive effort
	Material flexibility	The ability of equipment to handle variations in key dimensional and metallurgical properties of inputs
	Routing flexibility	The ab ility to vary machine visitation sequences for processing a part
	Material handling flexibility	The ability of the material handling system to move material effectively through the plant
	Program flexibility	The ability of equipment to run unattended for long periods of time
Tactical Flexibilities (Plant level)	Mix flexibility	The ability of a manufacturing system to switch flexibilities between different products in the product mix
	Volume flexibility	The ability of the manufacturing system to vary aggregate production volume economically
	Expansion flexibility	The ability to expand capacity without prohibitive effort
	Modification flexibility	The ability of the manufacturing process to customize products through minor design modifications
Strategic Flexibilities (Firm Level)	New product flexibility	The ability of the manufacturing system to introduce and manufacture new parts and products
	Market flexibility	The ability of the manufacturing system to adapt to or influence market changes

and different dimensions to it. According to Ansoff, (1965), flexibility can be measured by two proxy objectives: external flexibility achieved through a diversified pattern of product-market investments, and internal flexibility through liquidity of resources. Similarly Roberts and Stockport (2009) concluded with two distinct approaches to defining strategic flexibility-external and internal. Dangayach and Deshmukh (2001) identified various dimensions of flexibility. They classified it into structural flexibility and infrastructure flexibility. It was concluded that infrastructure flexibility attributes are more preferred by Indian manufacturers as compared to structural flexibility. The various types of flexibility are distinguished by the speed of response and the variety of capabilities related to each type (Volberda, 1996).

Advanced Manufacturing Technologies

Advanced manufacturing technologies now a day have been widely used by manufacturing organizations all over the world. AMTs refer to manufacturing process technologies that use computers to store and manipulate data (Dean *et al*., 1992). Likewise any other management concept, AMT is a multi dimensional and multi construct concept. AMTs have been described in different contexts by different authors.

Beaumont *et al*., 2002 have described AMT as a group of computer-based technologies, including CAD, CNC machines, direct numerical control (DNC) machines, RO, flexible manufacturing systems (FMS), automated storage and retrieval system (AS/RS), automated material handling systems (AMHS), automated guided vehicles (AGV), rapid prototyping (RP), MRP, statistical process control (SPC), manufacturing resource planning (MRP II), enterprise resource planning (ERP), activity-based costing (ABC), and office automation (OA).

Boyer and Pagell (2000) have divided AMTs into three dimensions viz. designed-based, manufacturing and administrative AMTs. Designed based AMTs is the technologies that shorten design period time, reduce product cost and offer opportunity to enterprises to occupy the market in advance, such as CAD, CAE, and CAPP, etc. Manufacturing AMTs guarantee the quick and economical communications in the enterprise such as FMS, GT, and CNC. Administrative AMTs includes real production technologies, such as EDI, OA, DSS and MRP. Youssef (1992) and Burgess and Gules (1998) classified AMTs as hard-based and soft-based AMTs. Hard-based AMT refers mainly to physical technologies used in engineering, processing and administration; while soft-based AMTs covers Total Quality Management (TQM) and JIT.

Dangayach and Deshmukh (2001) have categorized various technologies into two flexibility dimensions namely structural and infrastructural. Structural flexibility has CAD, CAE, CAPP, CNC, DNC, RO, CM, FMS, AGV, ASRS etc as its attributes and the attributes chosen for infrastructural flexibility are MRP, MRPII, ERP etc.

Design of Study

The methodology employed to study the impact of AMT, IF and TC on NPF and MFF has been depicted in figure 1.

Survey Questionnaire and Respondent Profile

In this study, a reasonably large number of manufacturing organizations have been extensively surveyed, to assess the flexibility in the Indian manufacturing industries. Survey of medium and large scale Indian manufacturing industries had been carried out through a specially designed questionnaire for understanding and assessing the prevailing situations. For effectively conducting the survey, the questionnaire has been designed through extensive literature review and validated through peer review from academicians, consultants, and senior managers from the industry. The questions framed are based on five points scale ranging from 1 to 5.

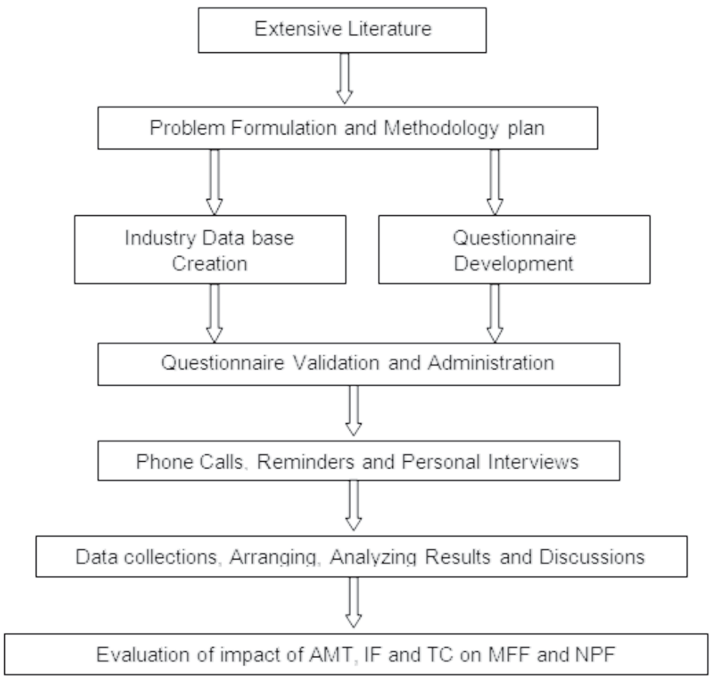

Figure 1: Methodology Used for the Study

Data collection was undertaken in three stages. The first stage involved detailed discussions with manufacturing executives in selected plants in different organizations, to confirm questionnaire validity and sample frame characteristics. The objective is to confirm that responses were based on correct interpretations of the questions. In the second stage, a final structured survey questionnaire was generated and mailed to 800 members chosen at random from among the membership of the Confederation of Indian Industry (CII) and ACME members. During the third stage, a reminder with a duplicate survey was sent to all nonrespondents to the initial mailing. 112 responses were received, constituting a response rate of 14%. This compares well with the response rates for studies in operations management (Handfield and Pannessi, 1995; Suarez *et al.*, 1996). A comparison \between the respondents to our first and second mailings revealed no significant differences in terms of organization size or respondent level. Elimination of unusable responses resulted in 102 responses.

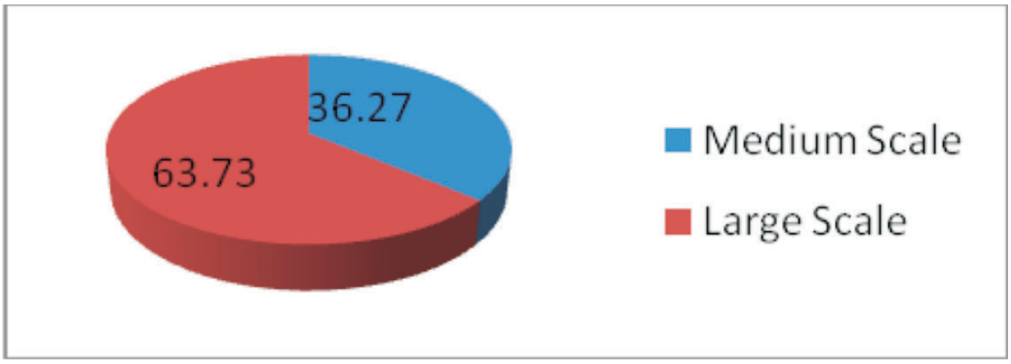

Figure 2: Breakdown of Responses

Reliability of Data

Table 2 depicts the descriptive statistics to study the impact of AMT, IF and TC on NPF and MFF in Indian manufacturing industry. Cronbach's alpha (á) values for all the constructs is more than 0.5, which is considered adequate for exploratory research (Flynn *et al.*, 1990; Forza, 2002; Kothari, 2004). SPSS 17.0 was used for this purpose.

Table 2

S. No.	Variable	Items/Factors of variable	Cronbach's alpha (á)
1	AMT	Computerized Numerical Controlled Machines NC/CNC etc.	0.898
		Robotics.	
		Flexible Manufacturing Systems (FMS).	
		Automatic Material Handling Systems.	
		Automatic Storage and Retrieval System (AS/RS).	
		Computer Aided Process Planning (CAPP) & Group Technology.	
		Computer Aided Design (CAD).	
		Computer Aided Inspection / Testing.	
2	IF	Manufacturing Resource Planning (MRP II).	0.859

		Material Requirement Planning (MRP).	
		Statistical Process Control (SPC).	
		Enterprise Resource Planning (ERP).	
		Office Automation (OA).	
3	**TC**	Technology plays an important role in your organization's business strategy	0.910
		Your organization is well aware of its main technology priorities.	
		Sufficient funds are allocated every year for upgrading existing technology.	
		Proper training is provided for existing technology utilization.	
		Your organization knows which technologies to outsource and which to develop internally.	
		Sufficient funds are allocated every year for introducing new technology.	
		Your organization has proper system to assess technological opportunities.	
		Your organization is well aware of the new technologies relevant to them.	
		Proper procedure is adopted for buying new technologies.	
		Your organization has list of all the vendors from where the technology is to be bought.	
		Your organization gets grant from external agencies for acquiring new technologies.	
		The employees are provided proper training when a new technology is introduced in your organization.	
		Your organization has foreign collaborations for new technology adoption.	
		Help from professional consultants is taken for new technology utilization.	
		Outside people are recruited when a new technology is adapted.	
		Benefits of new technology implementation are explained thoroughly.	
		Employees are shifted within the organization for proper utilization of the new technologies.	
4	**NPF**	Your organization has ability to introduce new product as soon as its need arises.	0.886
		Your organization is able to launch new products with minimum possible lead time.	
		Your organization is able to introduce and manufacture new products at a low cost.	
		Suppliers can provide new components/parts when required.	
		Manufacturing system performance is not affected due	

	New products can be manufactured quickly on the existing system.	
	Modifications in the existing products can be easily accommodated in the manufacturing system.	
	The performance of manufacturing system is not affected by changes in product design.	
	Your organization has ability to vary the product mix with minimal setup time.	
	Your organization has ability to operate at varying production levels.	
	Varying manufacturing schedules can be handled.	
	Changes in product volume can be handled without affecting the manufacturing system performance.	
	Production sequence can be changed.	
	The employees have ability to perform wide range of manufacturing tasks effectively.	
	The equipment/machines have ability to perform different operations economically.	
	Various batch sizes can be operated at different production output levels economically.	

Table 3: Pearson Correlation, Variance within the Group and Variance between the Groups for All the Variables.

		AMT	IF	TC	NPF	MFF
AMT	Pearson Correlation	1	.788(**)	.665(**)	.387(**)	.386(**)
	Sig. (2-tailed)		.000	.000	.000	.000
	Sum of Squares and Cross-products	100.821	74.187	44.803	32.557	26.368
	Covariance	.998	.735	.444	.322	.261
	N	102	102	102	102	102
IF	Pearson Correlation	.788(**)	1	.655(**)	.352(**)	.443(**)
	Sig. (2-tailed)	.000		.000	.000	.000
	Sum of Squares and Cross-products	74.187	87.815	41.144	27.660	28.239
	Covariance	.735	.869	.407	.274	.280
	N	102	102	102	102	102
TC	Pearson Correlation	.665(**)	.655(**)	1	.524(**)	.559(**)
	Sig. (2-tailed)	.000	.000		.000	.000
	Sum of Squares and Cross-products	44.803	41.144	44.962	29.433	25.486
	Covariance	.444	.407	.445	.291	.252
	N	102	102	102	102	102
NPF	Pearson Correlation	.387(**)	.352(**)	.524(**)	1	.680(**)
	Sig. (2-tailed)	.000	.000	.000		.000
	Sum of Squares and Cross-products	32.557	27.660	29.433	70.138	38.704
	Covariance	.322	.274	.291	.694	.383
	N	102	102	102	102	102
MFF	Pearson Correlation	.386(**)	.443(**)	.559(**)	.680(**)	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	Sum of Squares and Cross-products	26.368	28.239	25.486	38.704	46.177
	Covariance	.261	.280	.252	.383	.457
	N	102	102	102	102	102

Data Analysis

Table 4: Results of Regression Analysis

Performance factor	Significant factor	Beta value	t- value	p- value	R/ R^2 value	F value
NPF	TC	0.524	6.154	0.000	0.524/0.275	37.873
MFF	TC	0.559	6.748	0.000	0.559/0.312	45.530

From the extensive literature survey and critical examination of Indian manufacturing industry, it has been found out that few organizations have made reasonably signiûcant interventions regarding adapting manufacturing flexibility in a serious manner. In the present study, the target respondents have been the organizations that have made serious interventions in the field of strategic flexibility. The responses thus received and are compiled for analyzing them critically to ascertain the performance of the Indian industry regarding various strategic flexibility related issues.

In order to establish relationships between manufacturing flexibility dimensions (dependent variables) and various core capabilities (independent variables), bivariate correlation, multiple regression have been employed. The correlations have been worked out to ascertain the signiûcant factors contributing to achieve strategic flexibility in the organizations. Only those pairs with Pearson correlation greater or equal to 40 percent and statistically signiûcant at 1 percent level of significance are considered as having a strong association. The objective has been to extract those factors, which are signiûcantly associated with strategic flexibility dimensions.

The notations used and their meanings are given below:

r - Pearson correlation coefficient

â - Regression coefficient (beta coefficient)

R - Multiple correlation co-efficient

As an initial step, the pearson correlations values have been calculated to find the level of inter correlation among dynamic capabilities and dimensions of strategic flexibility. The correlation coefficients (r) are found to be high and signiûcant at p = 0.01 significance level in most of the cases. This indicates that most of the dynamic capabilities are signiûcantly related to various dimensions of strategic flexibility. The correlation (r) values through exploratory method using SPSS 20.0 are shown in table 3.

The correlation values indicate a strong and significant correlation between technological capabilities (TC) with new product flexibility (0.524**) and manufacturing flexibility (0.559**). The results of stepwise regression analysis are depicted in table 4 alongwith corresponding values of R/R^2, P values and F values. The results indicate that technological capabilities have emerged as a major factor that impact new product flexibility and manufacturing flexibility. The other two factors have not shown any significant effect on these types of flexibilities.

Conclusion

This paper provides the first empirical evidence of such a relationship with a relative choice amongst organizational capabilities for achieving manufacturing flexibility in manufacturing organizations in India.

The results reveal that technological capabilities have strengthened the manufacturing organizations to respond effectively and efficiently to unpredictable and hypercompetitive business environment. The impact of technological capabilities has come out to be highly significant in developing the flexibility dimensions. The results indicate that in order to respond to various market fluctuations, an organization must be capable of doing innovations. It can be concluded that the organizations having clear vision regarding their technological priorities and capable of doing innovations can effectively respond and survive in highly turbulent market conditions.

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