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An empirical exploration of Agile manufacturing for enhanced business performance in Indian manufacturing industry

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Abstract

Purpose – The purpose of this paper is to investigate the effects of agile manufacturing practices on business performance of Indian medium and large-scale manufacturing industry.
Design/methodology/approach – A survey questionnaire was designed to attain the research objectives. Agile manufacturing questionnaire was sent to around 500 randomly selected manufacturing organizations in the northern spectrum of India through e-mails and posts, out of which 154 usable responses have been received. This study investigates the inter-relationships between various agile manufacturing implementation practices and business performance measures using various statistical techniques. This paper deploys Games–Howell hoc test to establish the statistical significance of business performance improvements, progressively accrued over a reasonable period of time, through holistic agile manufacturing implementation.
Findings – The paper validates the contribution of agile manufacturing toward realization of the significant improvements in various business performance measures such as customer-related achievements, financial achievements, business-related achievements, operational achievements, employee-related achievements, and supplier-related achievements. Further, the discriminant validity test has been used in this paper for classifying highly successful and moderately successful organizations.
Research limitations/implications – The paper only concentrated on manufacturing organizations in northern India. The results of this paper cannot generalize across all the sectors and spectrum of Indian manufacturing organizations.
Originality/value – This paper develops an insight into the strong potential of agile manufacturing implementation practices in affecting business performance measures.

Keywords Manufacturing industry, Business performance, Agile manufacturing

Paper type Research paper

1. Introduction

Globalization intensified the competition among manufacturer and fueled the customers to expect more and more innovative products with superior quality and at lower cost (Dubey and Gunasekaran, 2015; Thilak *et al.*, 2017; Goswami and Kumar, 2018). In order to sustain and achieve organizational goals in dynamic business environment, it is imperative for manufacturing industry to adopt new and revolutionary initiatives (Iqbal *et al.*, 2018). This situation has motivated the manufacturing industry for casting off traditional paradigms such as craft production and mass production, and sparked the urgent need to adopt an advanced paradigm named as "Agile manufacturing" to meet the implicit demand of the consumers (Matawale *et al.*, 2016).

Agile manufacturing has emerged as a vital characteristic for successful survival of the organizations in today's dynamic global markets (Matawale *et al.*, 2016). Agile manufacturing refers to the capability of the manufacturer to develop products that meet consumer's dynamic demands in alignment with business environment changes, without compromising with quality. Agile manufacturing is a leading manufacturing approach that organizations exploit to

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boost their business performance (Vazquez-Bustelo *et al.*, 2007; Inman *et al.*, 2011). Agility in organizational structure is an indispensable requirement for success and competitive advantage. The hypercompetitive business environment encourages manufacturer to adopt agile manufacturing, but it faces significant challenges, such as inefficiency of top management, slow decision-making process, lack of appropriate technologies, poor usages of information system in organization, organizational structure and culture, poor relationship formation and management with suppliers (Hasan *et al.*, 2007). Agility acquisition has becoming increasingly important for manufacturing organizations and is proven as a profit-generating element in modern-day business environment. Agile manufacturing generates numerous benefits for the manufacturing organizations (Hormozi, 2001). Agile manufacturing positively impacts organizational performance in cost, quality, delivery and flexibility, and market share (Adeleye and Yusuf, 2006; Vazquez-Bustelo *et al.*, 2007; Gore *et al.*, 2009; Hallgren and Olhager, 2009; Inman *et al.*, 2011; Leite and Braz, 2016; Nabass and Abdallah, 2018). Organizational agile capabilities have a considerable role in new product development (Leite and Braz, 2016). Successful implementation of agile manufacturing builds cooperation to enhance competitiveness (Hormozi, 2001; Giachetti *et al.*, 2003), change in organizational culture to master change and uncertainty (Gunasekaran, 1999; Giachetti *et al.*, 2003; Ren *et al.*, 2003; Raj *et al.*, 2014), empowerment of employee (Gunasekaran, 1999; Sharp *et al.*, 1999; Breu *et al.*, 2002; Gore *et al.*, 2009; Raj *et al.*, 2014) and fosters customer enrichment (Ren *et al.*, 2003; Raj *et al.*, 2014; Dubey and Gunasekaran, 2015). Dubey *et al.* (2018) mentioned three properties, namely "agility," "adaptability" and "alignment," which enables manufacturing industry to respond rapidly to uncertainties in business environment and compete globally. Agile manufacturing lays high emphasis on maximizing the responsiveness to demands of customers in growing competitive environment and is only possible through the coordination of system architecture and technology resources in the company. The manufacturing industry has shown huge interest in the development of agile manufacturing system (Giachetti *et al.*, 2003). Giachetti *et al.* (2003) cited flexibility and agility as two structural properties of the manufacturing system that must be incorporated into system architecture, operating policies, technologies and organization to adapt to the abruptly changing nature of markets. The remaining paper is organized as follows: Section 2 portrays a literature review of agile manufacturing and business performance. Section 3 explains the research methodology used in the present study. Sections 4–7 deal with detailed analysis of empirical data collected through a survey and its results interpretation. Section 8 is dedicated to conclusion of the present study. At last, section 9 provides the research limitation and future directions of study.

2. Literature review

2.1 Agile manufacturing

Agility as defined in the Oxford Dictionary is simply "*Ability to move quickly and easily.*" Some researchers (Goldman and Nagel, 1993; Gunasekaran, 1999; Hormozi, 2001; Sarkis, 2001; Gunasekaran and Yusuf, 2002; Jin-Hai *et al.*, 2003; Saleeshya and Babu, 2012; Routroy *et al.*, 2015) have pointed out that agile manufacturing has evolved from a number of existing systems of management and technologies, which include lean manufacturing (Robertson and Jones, 1999) and flexible manufacturing (Pullan *et al.*, 2010; Thilak *et al.*, 2017). Iqbal *et al.* (2018) claimed that agile manufacturing is strongly connected with other systems by stating that "lean (TQM and JIT), along with management, and internal and external infrastructure enablers, are antecedent to AM," These "manufacturing paradigm" can be seen as necessary but not sufficient for an agile organization. After Second World War, cost effectiveness and delivery time were the overriding manufacturing factors owing to incompetence of manufacturing sector in meeting the high demand (Draaijer, 1992), resulting in mass production, incorporating high automation of manufacturing system (Goldman and Nagel, 1993). Mass production systems produced large quantity of uniform products at lower unit cost. Manufacturing world was ruled by economies of scales, and the only way to good money was mass production and upmost utilization of firm's resources. In early 1980s, several companies had started to concentrate on quality management. With the emerging response of customer to strengthen this trend, others were also motivated to adopt quality management. Consequently, many technology and management-related developments were observed in market like flexible manufacturing, lean manufacturing, production planning and control, computer-aided design and manufacturing, total quality management control, quality circle, quality function deployment and many more intended to attain superior performance and quality at a lower cost that promise competitive advantage, which questioned the fitness of mass production to future industrial situations. Industrial sector has been forced to attain more flexibility, retaining optimum quality and minimum cost.

The term "Agile Manufacturing" was originally coined in an important report titled "21st Century Manufacturing Enterprise Strategy" published by Iacocca institute at Lehigh University, USA in 1991 (Khoo and Loi, 2002; Vazquez-Bustelo and Avella, 2006; Garbie *et al.*, 2008). In this report, the phrase "Agile Manufacturing" characterized a unique form of industrial competition for US companies where changes may occur in roles of customer, supplier and competitor firms (Goldman and Nagel, 1993) to gain advantage of opportunities in the market in order to satisfy individual customer preferences. Earlier, success of a manufacturing firm could be quantified by its cost effectiveness in producing a single product (Draaijer, 1992), but now it seems to be quantified in terms of agility, flexibility and versatility to keep pace with changes in marketplace, uncertainty in customer demand and advances in technology. The focus has shifted to provide high-quality products at improved delivery time to create customer satisfaction and delight. Agile manufacturing systems are capable of producing high-quality and low-unit cost products in compressed time, even in smaller quantities (Garbie *et al.*, 2008). It favors modular design approach (Gunasekaran, 1999; Dowlatshahi and Cao, 2006; Sindhwani and Malhotra, 2017). Agile manufacturing has received increasing attention from both academicians and industry professionals, and developed gradually from a niche topic into a broad cross-disciplinary research area. Over the last two decades, numerous researches have reported on defining agility. However, there is no general agreement among researchers on common terminology in defining agility (Vazquez-Bustelo *et al.*, 2007; Nabass and Abdallah, 2018). Gunasekaran (1998) described AM as "the capability to survive and prosper in a competitive environment of continuous and unpredictable change by reacting quickly and effectively to changing markets, driven by customer-designed products and services." Hormozi (2001, p. 132) defined agility as "[…] being able to reconfigure operations, processes, and business relationships efficiently while at the same time flourishing in an environment of continuous change." He further mentioned that successful implementation of agile manufacturing needs changes in five thrust areas: "government regulation," "business cooperation," "information technology," "reengineering" and "employee flexibility." Nabass and Abdallah (2018) defined agile manufacturing as "the firm's exceptional capacity to adjust its internal processes and activities through utilizing appropriate managerial and manufacturing methods and tools to respond to market changes."

2.2 Business performance

The measurement, improvement and management of the business performance is the primary concern of every organization worldwide. Alkunsol *et al.* (2018) described business performance as "a set of management and critical procedures that allows the management of an organization to accomplish one or more pre-selected goals." Agile manufacturing has found new vigor and purpose to increase customer satisfaction and business performance owing to increasing emphasis on sustainability. Agile manufacturing is emerging as an imperative strategy for enterprises and its impact on business performance is appreciated in all industrial sectors. The assessment of the organizational performance has become very important in the development of the organizational objectives and goals. Antunes *et al.* (2017) defined performance evaluation as "the process to quantify the efficiency and effectiveness of production systems." Agile manufacturing has been recognized as a promising procedure in achieving greater customer satisfaction and superior business performance by firms. The adoption of agile manufacturing principles helps the organization to reform itself according to the dynamic needs of customers and to reduce the time and cost of the new product and process development (Vinodh *et al.*, 2010). An organization must effectively coordinate among the key enablers of agile manufacturing in dynamic business environment to achieve business competitiveness. Agile manufacturing has a decisive role in the socio-economic development of the Indian manufacturing industry that uses diverse initiative to enhance business performance. Nabass and Abdallah (2018) stated that business performance refers to "the ability of organizations to handle several external factors, such as market characteristics, organization position, and ability to handle market turbulence to increase performance in customer satisfaction, market growth, and profitability." Agile manufacturing adoption requires proper leveraging of agile manufacturing principles with operational and financial benefits to translate market opportunities into business excellence. Uncertainty in the business environment has caused agile manufacturing to emerge as an essential strategy for business excellence. Successful deployment of agile manufacturing principles would enable the organization to minimize manufacturing lead times, delight its customers and to gain a competitive advantage against competitors.

The manufacturing sector has regarded agile manufacturing as a significant route to attain sustainability in changing business environment and responsiveness to volatile customer demands (Vazquez-Bustelo *et al.*, 2007). Over the years, several studies have been carried out to assess organizational agility or to develop frameworks for the implementation of agile manufacturing, which can enlighten the route to achieving business excellence by practicing agile manufacturing. Prince and Kay (2003) discussed the application of enhanced production flow analysis to identify virtual groups, which enables the manufacturing industry with functional layouts to improve their manufacturing performance. Ren *et al.* (2003) empirically investigated the application of artificial neural networks to identify, segregate and quantify the influence of agility attributes on competitive capabilities, namely speed, cost, quality, innovation, flexibility and proactivity, of the enterprise. Cao and Dowlatshahi (2005) investigated the synergic and interactive impact of virtual enterprise and information technology on business performance by analyzing the data collected from manufacturing companies in an agile manufacturing environment.

Vazquez-Bustelo *et al.* (2007) found that agile manufacturing application has boosted the operational, market and financial performance of the firm, simultaneously promoting competitive manufacturing strength. Inman *et al.* (2011) investigated the linkage between Just-in-time, agile manufacturing, operational performance and firm performance. Nafei (2016) highlighted the need to pay more attention to strengthen the constructs of organizational agility to enhance organizational excellence.

Chan *et al.* (2017) corroborated that supply chain agility has a significant contribution to enhancing organizational performance. The authors further stated that strategic and manufacturing flexibility, intensively, have an instrumental effect on supply chain agility and organizational performance. Pantouvakis and Bouranta (2017) proposed a theoretical framework linking organizational learning culture to customer relationship quality, through agility, and investigated how the service sector responds to the continuously changing business environment. They examined the effect of organizational learning culture on customer relationship quality, through agility. Potdar and Routroy (2017) carried out the performance evaluation of an Indian auto component manufacturer through a set of key performance indicators for agile manufacturing using fuzzy analytic hierarchy process and performance value analysis.

Ghobakhloo and Azar (2018) collected cross-sectional data from 189 automotive parts manufacturing industries in Iran, through a questionnaire-based survey and tested the relationship among advanced manufacturing technology, lean manufacturing, agile manufacturing and business performance. They found that performance wise, there is a significant difference in lean manufacturing and agile manufacturing; lean manufacturing leads to operational performance, on the other hand, agile manufacturing results in enhanced marketing and financial performance. They concluded that both lean manufacturing and agile manufacturing could co-exist in a single unit and manufacturing industry can be flourished with better business performance with co-existence of both lean manufacturing and agile manufacturing. Nabass and Abdallah (2018) examined the influence of agile manufacturing on business performance and operational performance dimensions of cost, quality, delivery and flexibility in the manufacturing sector in Jordan. They found that agile manufacturing has a positive and significant effect on business performance and operational regarding considered dimensions. An elaborated literature review delineates that relatively limited studies have investigated the effect of AM initiatives on business performance of manufacturing industry and in emerging economies, such as India. Therefore, the aim of this study is to contribute to AM literature by identifying the different enablers of AM and to empirically investigate their impact on business performance dimensions of Indian manufacturing industry.

3. Research methodology

The present study has been accomplished in the medium- and large-scale Indian manufacturing industry that has successfully implemented or is at various stages of agile manufacturing implementation. In Indian context, a medium-scale industry is one where annual turnover is > Rs75 crores but does not exceed Rs250 crores and in large-scale industry, annual turnover is > 250 crores. The present work considers a manufacturing plant as a unit of analysis, targeting one respondent from each group to receive the answer on the designed questionnaire. The northern spectrum of Indian manufacturing industry is considered as population for the research work. The sample size consists of different industry types that include Industrial and commercial machinery, electronic and electrical equipment, transportation equipment, food, and kindred products, textile mill products, paper, and allied products, chemical and allied products, primary metal industry and others. The survey method was employed to collect responses from manufacturing organizations. A survey questionnaire was designed to attain the research objectives. The variables included in the questionnaire were adopted from the elaborated literature review (Ren *et al.*, 2003; Dowlatshahi and Cao, 2006; Vazquez-Bustelo *et al.*, 2007; Hallgren and olhager, 2009; Hasan *et al.*, 2009; Eshlaghy *et al.*, 2010; AL-Tahat and Bataineh, 2012; Saleeshya and Babu, 2012; Mishra *et al.*, 2013; Aravindraj and Vinodh, 2014; Dubey and Gunasekaran, 2015; Routroy *et al.*, 2015; Samantra *et al.*, 2015; Leite and Braz, 2016; Kumar *et al.*, 2017; Sindhwani and Malhotra, 2017; Potdar and Routroy, 2017; Nabass and Abdallah, 2018) and validated through discussion held with practitioners, academicians and the industry. The suggestions given by them have been incorporated into the questionnaire to make it more useful and relevant to research objectives. A four-point Likert scale has been employed to get responses on agile manufacturing questionnaire to ascertain the current status of agile manufacturing implementation and its influence on business performance enhancement. Agile manufacturing questionnaire was sent to ~ 500 randomly selected manufacturing organizations through e-mails and posts, out of which 154 usable responses have been received, giving a response rate of 30.8 percent, which is fairly good (Adeleye and Yusuf, 2006; Dowlatshahi and Cao, 2006; Vazquez-Bustelo *et al.*, 2007; Inman *et al.*, 2011; Chakravarty *et al.*, 2013; Chan *et al.*, 2017; Ghobakhloo and Azar, 2018; Iqbal *et al.*, 2018) and further processed for scrutiny to ascertain the performance of industries regarding agile manufacturing-related issues. The methodology employed in the present study is shown in Figure 1.

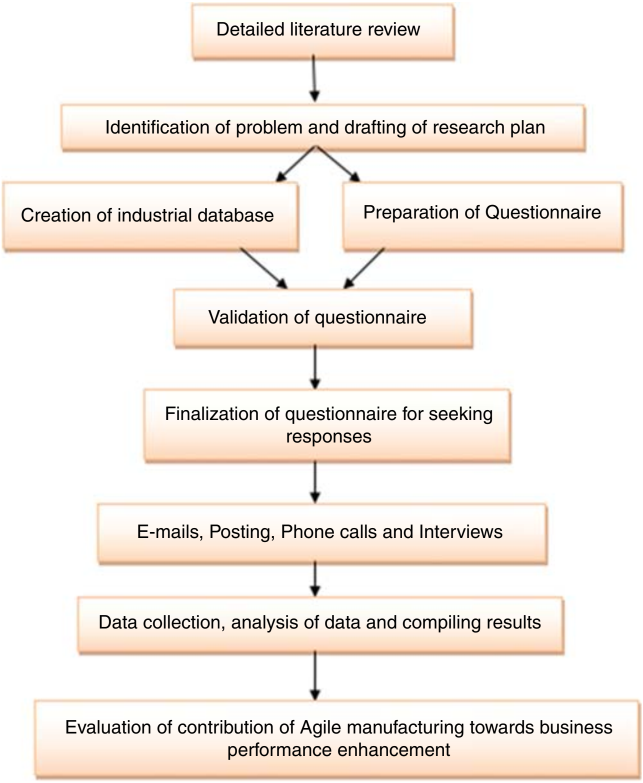

Figure 1.
Research methodology

A comprehensive and relevant agile manufacturing questionnaire is designed and employed to collect the required data to fulfill the research objectives. The survey instrument starts with general organizational aspects that include name and address of the company, product manufactured, present annual turnover, number of employees, market share. Further, the questionnaire was divided into various sections.

Section 1 seeks information about the current status of agile manufacturing practices, the query about various issues like leadership support, human resource-related issues, organizational culture-related issues, supplier-associated issues, customer-related issues, innovation, concurrent engineering, and information technology. Section 2 collects data regarding business performance achievements through agile manufacturing. Section 3 seeks information regarding barriers to the successful implementation of agile manufacturing.

The agile manufacturing questionnaire includes the following sections:

(1) General organizational information

(2) Leadership support (X1)

(3) Human resource-related issues (X2)

(4) Organizational Culture-related issues (X3)

(5) Supplier-related issues (X4)

(6) Customer-related issues (X5)

(7) Innovation (X6)

(8) Concurrent engineering (X7)

(9) Information technology (X8)

(10) Business performance achievement through agile manufacturing implementation (Y1–Y6):

- Customer-related achievements (Y1)
- Financial achievements (Y2)
- Business-related achievements (Y3)
- Operational achievements (Y4)
- Employee-related achievements (Y5)
- Supplier-related achievements (Y6)

(11) Barriers in successful implementation of agile manufacturing.

Further, in order to establish relationship among agile manufacturing implementation practices (independent variable) and business performance enhancements (dependent variable), different statistical techniques like Cronbach's α, covariance matrix, Pearson correlation coefficient, multiple regression analysis, canonical correlation analysis, multiple/post-hoc group comparisons in ANOVA and discriminant validity analysis has been employed using Software Package for Social Sciences.

Further, the present work is based on the following hypothesis:

H1. There is a relationship between dependent (Y1–Y6) and independent variables (X1–X8) of agile manufacturing.

H2. Independent variables (X1–X8) have significant effect on business performance (Y1–Y6) of agile manufacturing.

H3. Implementation period has a significant role in successful implementation of agile manufacturing.

H4. Agile manufacturing implementation has a high success rate.

4. Relationship between various agile manufacturing practices and business performance measures

4.1 Reliability test and validity of segments

The Cronbach's α coefficient for different segments of agile manufacturing questionnaire was evaluated to ensure the reliability of the respondent data gathered through the survey and tabulated in Table I. The value of Cronbach's α for various segments of agile manufacturing, taken in the study, was observed to be > 0.7, which is usually considered to be a satisfactory value to check the internal consistency of data (Nunnally, 1978, p. 245).

4.2 Inter-item covariance test

Table II reflects the inter-item covariance matrix showing the covariance of significant areas of agile manufacturing and business performance measures. The data reveal that all the respective covariance values of variables within the group are higher than the covariance value of the variables outside the group.

S. No.		Cronbach's α
	Description of "agile manufacturing questionnaire" segment	
X1	Leadership support	0.84
X2	Human resource-related issues	0.87
X3	Organizational culture-related issues	0.84
X4	Supplier-related issues	0.78
X5	Customer-related issues	0.88
X6	Innovation	0.85
X7	Concurrent engineering	0.73
X8	Information technology	0.86
	Business performance achievements through agile manufacturing implementation	
Y1	Customer-related achievements	0.920
Y2	Financial achievements	0.861
Y3	Business-related achievements	0.931
Y4	Operational achievements	0.914
Y5	Employee-related achievements	0.921
Y6	Supplier-related achievements	0.893

Table I. Cronbach's α for various segments of agile manufacturing questionnaire

	X1	X2	X3	X4	X5	X6	X7	X8	Y1	Y2	Y3	Y4	Y5	Y6
X1	0.012	0.010	0.010	0.007	0.007	0.009	0.008	0.006	0.008	0.007	0.007	0.009	0.008	0.009
X2	0.010	0.016	0.013	0.011	0.011	0.012	0.011	0.009	0.012	0.008	0.014	0.015	0.014	0.014
X3	0.010	0.013	0.014	0.010	0.010	0.011	0.012	0.009	0.011	0.008	0.012	0.014	0.014	0.013
X4	0.007	0.011	0.010	0.015	0.010	0.010	0.011	0.009	0.011	0.007	0.012	0.012	0.012	0.013
X5	0.007	0.011	0.010	0.010	0.013	0.010	0.010	0.007	0.010	0.007	0.011	0.012	0.011	0.011
X6	0.009	0.012	0.011	0.010	0.010	0.016	0.012	0.010	0.010	0.006	0.012	0.015	0.013	0.012
X7	0.008	0.011	0.012	0.011	0.010	0.012	0.017	0.010	0.010	0.008	0.012	0.012	0.011	0.013
X8	0.006	0.009	0.009	0.009	0.007	0.010	0.010	0.018	0.012	0.009	0.012	0.014	0.013	0.014
Y1	0.008	0.012	0.011	0.011	0.010	0.010	0.010	0.012	0.021	0.013	0.018	0.019	0.018	0.020
Y2	0.007	0.008	0.008	0.007	0.007	0.006	0.008	0.009	0.013	0.021	0.014	0.015	0.014	0.013
Y3	0.007	0.014	0.012	0.012	0.011	0.012	0.012	0.012	0.018	0.014	0.025	0.024	0.023	0.021
Y4	0.009	0.015	0.014	0.012	0.012	0.015	0.012	0.014	0.019	0.015	0.024	0.032	0.026	0.024
Y5	0.008	0.014	0.014	0.012	0.011	0.013	0.011	0.013	0.018	0.014	0.023	0.026	0.029	0.024
Y6	0.009	0.014	0.013	0.013	0.011	0.012	0.013	0.014	0.020	0.013	0.021	0.024	0.024	0.028

Table II. Inter-item covariance matrix

5. Analysis and results for relationship between agile manufacturing practices and business performance measures

5.1 Pearson's correlation analysis

Further to check the correlation among various agile manufacturing input variables and business performance measures, Pearson's correlation analysis is used to examine the presence of multicollinearity and to explore the relationship among significant areas of agile manufacturing and business performance measures. The bivariate correlation test, subjected to a two-tailed test at a significance level of 0.01 was performed to investigate the bivariate relationship between considered variables. The following recommendations, proposed by Rowntree (1987, p. 170) are used for interpretation of the strength of relationship between two variables:

(1) If correlation coefficient $(r) =$ 0.0– 0.2, then strength of the relationship is very weak or negligible.

(2) If correlation coefficient $(r) =$ 0.2–0.4, then strength of the relationship is weak or low.

(3) If correlation coefficient (r) = 0.4–0.7, then strength of the relationship is moderate.

(4) If correlation coefficient (r) = 0.7–0.9, then strength of the relationship is strong or high.

(5) If correlation coefficient (r) = 0.9–1.0, then strength of the relationship is very strong or very high.

Table III depicts the correlation matrix, indicating the Pearson's correlation coefficient (r) between significant areas of agile manufacturing and business performance indicators to highlight the level of correlation among them. The value of Pearson's correlation coefficient (r) ranges from 0.335 to 0.706, which indicates that the variables have positive and moderate correlation with each other. Thus, *H1*: there is a relationship between dependent (Y1–Y6) and independent variables (X1–X8) of agile manufacturing holds true. The highest value of correlation coefficient (0.706) is for human resource-related issues (X2) and business-related achievement (Y3) and weakest value of correlation coefficient (0.335) is for innovation (X6) and financial achievement (Y2).

5.2 Multiple regression analysis

To find out the significant factors of the current study, multiple regression has been used. Table IV represents the results of multiple regression test to examine the contribution of

Table III. Pearson's correlation between agile manufacturing success factors and business performance measures

	X1	X2	X3	X4	X5	X6	X7	X8
Y1	0.502**	0.672**	0.632**	0.612**	0.586**	0.543**	0.536**	0.595**
Y2	0.441**	0.427**	0.443**	0.370**	0.457**	0.335**	0.412**	0.451**
Y3	0.422**	0.706**	0.649**	0.615**	0.622**	0.628**	0.570**	0.568**
Y4	0.467**	0.682**	0.672**	0.556**	0.593**	0.680**	0.537**	0.601**
Y5	0.433**	0.653**	0.661**	0.586**	0.592**	0.607**	0.510**	0.578**
Y6	0.479**	0.666**	0.655**	0.620**	0.566**	0.582**	0.583**	0.609**

Note: **Correlation is significant at the 0.01 level (two-tailed)

Table IV. Results of multiple regression test

	Significant factor	β value	t-value	p-value	R/R^2 value	Adjusted R^2 value	F-value	Durbin–Watson
Y1	X2	0.340	2.665	0.009	0.740/0.544	0.522	21.901	1.836
	X8	0.299	4.093	0.00007				
Y2	X1	0.290	2.883	0.005	0.586/0.344	0.308	9.494	1.554
	X5	0.324	2.764	0.006				
	X8	0.325	3.695	0.0003				
Y3	X2	0.468	3.824	0.0001	0.765/0.585	0.562	25.514	1.655
	X8	0.191	2.736	0.007				
Y4	X2	0.255	2.106	0.037	0.769/0.592	0.569	26.265	1.926
	X6	0.315	3.303	0.001				
	X8	0.266	3.835	0.0001				
Y5	X3	0.351	2.607	0.010	0.742/0.551	0.526	22.252	1.914
	X7	−0.200	−2.061	0.041				
	X8	0.260	3.577	0.0004				
Y6	X2	0.275	2.167	0.032	0.744/0.554	0.530	22.534	1.555
	X8	0.285	3.933	0.0001				

significant areas of agile manufacturing practices for attaining business performance enhancement in manufacturing organization. The terminology used is as follows:

$\beta =$ regression coefficient

$t =$ compare means of two groups

$P =$ significance factor

$R =$ multiple correlation coefficient

$R^2 =$ coefficient of determination

Adjusted $R^2 =$ the magnitude of alteration in dependent variables estimated by independent variables

Durbin–Watson value = a methodology to examine the existence of autocorrelation (an affiliation among values divided from each other by a given time lag) in residuals (prediction errors) by using regression analysis.

$F =$ variation between sample means/variation within the samples

Table IV indicates that the strengthening of the information technology (X8) infrastructure in manufacturing industry can have considerable positive effect in enhancement of performance parameters, customer-related achievements (Y1), financial achievements (Y2), business-related achievements (Y3), operational achievements (Y4), employee-related achievements (Y5), and supplier-related achievements (Y6); thus, supporting the literature and also highlighting the importance of information technology as the most fundamental and critical enabler of agile manufacturing in enhancing organizational performance. Further, it can be noticed that human resource-related issues (X2) also has a significant role in betterment of performance parameters customer-related achievements (Y1), business-related achievements (Y3), operational achievements (Y4), supplier-related achievements (Y6), which gives a clear indication that the manufacturing organizations are organizing agile manufacturing practice awareness and training programs for employees on regular basis and emphasizing on imparting multi-skilling and flexibility to employees.

Moreover, the table reveals that leadership support (X1) provides significant benefits in financial achievements (Y2). The data also highlight that organizational culture-related issues (X3) have shown a significant positive effect on employee-related achievements (Y5), which reveals that the organizations have developed well-defined system architecture to promote employee involvement in teamwork, to facilitate fast and decentralized decision making and encourage transparent communication at each level. Further, it is depicted from data that customer-related issues (X5) contribute significantly toward financial achievements (Y2), which indicates that the manufacturing industries have developed an efficient channel to anticipate and understand customer requirements. They have been working hard on achieving customer satisfaction and delight by providing effective after sale service and resolving customers' complaints.

The data also reveal that innovation (X6) contributes significantly toward operational achievements (Y4) clarifying that organizations have acquired the characteristics of knowledge acquisition, knowledge sharing and knowledge update for gearing organization performance and attain a competitive edge in the prevailing volatile economy. The data also highlight that concurrent engineering (X7) have shown a significant negative effect on employee-related achievements (Y5). This show that organizational structure of some of companies do not facilitate concurrency across the company. They must pay attention to provide multidisciplinary team working environment for concurrent execution of activities. Thus, *H2*: independent variables (X1–X8) have significant effect on business performance (Y1–Y6) of agile manufacturing holds true.

5.3 Canonical correlation analysis

In order to check the relationship among all agile manufacturing parameters with business performance measures, canonical correlation analysis was used. Table V reveals the results of

Table V.
Canonical correlation analysis between agile manufacturing practices (X1–X8) and business performance indicators (Y1–Y6)

Canonical parameters	Results with all variables		Results after deletion of X1		X2		X3		X4		X5		X6		X7		X8	
Canonical correlation	0.811		0.805		0.796		0.809		0.806		0.811		0.806		0.809		0.792	
Canonical root	0.658		0.648		0.634		0.654		0.650		0.658		0.650		0.654		0.627	
F-statistic probability	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	
Dependent variate	Canonical loadings	Cross loadings	Canonical loadings	Cross loadings	Canonical loadings	Cross loadings	Canonical loadings	Cross loadings	Canonical loadings	Cross loadings	Canonical loadings	Cross loadings	Canonical loadings	Cross loadings	Canonical loadings	Cross loadings	Canonical loadings	Cross loadings
Y1	−0.880	−0.714	−0.905	−0.729	−0.885	−0.704	−0.883	−0.714	−0.878	−0.708	−0.879	−0.713	−0.906	−0.731	−0.885	−0.716	−0.843	−0.668
Y2	−0.547	−0.444	−0.605	−0.487	−0.594	−0.472	−0.547	−0.442	−0.568	−0.458	−0.544	−0.441	−0.594	−0.479	−0.561	−0.454	−0.471	−0.373
Y3	−0.936	−0.760	−0.928	−0.747	−0.918	−0.731	−0.941	−0.761	−0.935	−0.754	−0.936	−0.759	−0.936	−0.755	−0.940	−0.761	−0.941	−0.745
Y4	−0.935	−0.758	−0.934	−0.752	−0.946	−0.752	−0.929	−0.752	−0.946	−0.763	−0.934	−0.758	−0.920	−0.742	−0.930	−0.752	−0.920	−0.729
Y5	−0.905	−0.734	−0.904	−0.728	−0.924	−0.736	−0.895	−0.724	−0.906	−0.730	−0.904	−0.734	−0.905	−0.730	−0.899	−0.728	−0.887	−0.703
Y6	−0.899	−0.729	−0.914	−0.736	−0.909	−0.723	−0.898	−0.726	−0.896	−0.723	−0.899	−0.729	−0.916	−0.738	−0.907	−0.734	−0.870	−0.689
Shared variance	0.742		0.762		0.759		0.739		0.748		0.741		0.759		0.746		0.701	
Redundancy index	0.488		0.494		0.480		0.484		0.486		0.488		0.494		0.489		0.440	
Independent variate	Canonical loadings	Cross loadings	Canonical loadings	Cross loadings	Canonical loadings	Cross loadings	Canonical loadings	Cross loadings	Canonical loadings	Cross loadings	Canonical loadings	Cross loadings	Canonical loadings	Cross loadings	Canonical loadings	Cross loadings	Canonical loadings	Cross loadings
X1	−0.585	−0.475	–	–	−0.621	−0.494	−0.585	−0.473	−0.597	−0.481	−0.584	−0.474	−0.609	−0.491	−0.591	−0.479	−0.555	−0.439
X2	−0.913	−0.741	−0.919	−0.740	–	–	−0.918	−0.742	−0.918	−0.740	−0.913	−0.741	−0.920	−0.742	−0.917	−0.742	−0.928	−0.735
X3	−0.869	−0.705	−0.881	−0.710	−0.895	−0.712	–	–	−0.877	−0.707	−0.869	−0.705	−0.877	−0.707	−0.871	−0.705	−0.870	−0.689
X4	−0.799	−0.649	−0.807	−0.650	−0.808	−0.643	−0.804	−0.650	–	–	−0.799	−0.648	−0.812	−0.655	−0.805	−0.651	−0.809	−0.641
X5	−0.783	−0.635	−0.796	−0.641	−0.802	−0.638	−0.785	−0.635	−0.790	−0.637	–	–	−0.794	−0.641	−0.786	−0.636	−0.784	−0.621
X6	−0.836	−0.678	−0.830	−0.669	−0.847	−0.674	−0.836	−0.676	−0.844	−0.680	−0.836	−0.678	–	–	−0.834	−0.675	−0.858	−0.679
X7	−0.723	−0.587	−0.737	−0.593	−0.736	−0.585	−0.728	−0.589	−0.728	−0.587	−0.723	−0.586	−0.738	−0.595	–	–	−0.724	−0.573
X8	−0.772	−0.627	−0.794	−0.640	−0.802	−0.639	−0.772	−0.625	−0.782	−0.630	−0.772	−0.626	−0.788	−0.636	−0.777	−0.629	–	–
Shared variance	0.625		0.681		0.626		0.610		0.635		0.626		0.635		0.645		0.636	–
Redundancy index	0.411		0.442		0.397		0.399		0.413		0.412		0.413		0.422		0.399	

canonical correlation analysis. The data depict strong canonical correlation function ($r = 0.811$ at F-statistic probability of < 0.001) between agile manufacturing success factors and business performance parameters. The value of redundancy indices was 0.488 and 0.411 for dependent and independent canonical variables, respectively. The redundancy index shows the amount of variance in a canonical variate in the canonical function. The canonical loading for various agile manufacturing practices (X1–X8) on the independent variate varies from 0.585 to 0.913. However, cross loadings for agile manufacturing practices on the independent variate extends from 0.475 to 0.741. The canonical loadings for criterion set of business performance parameters (Y1–Y6) on dependent variate also indicate strong loading (0.547 to 0.936). On the other hand, the cross loadings for criterion set of business performance parameters (Y1–Y6) on dependent variate ranged from 0.444 to 0.760.

Further, the stability runs were executed by dropping one independent variate at a time, owing to moderate specimen size, for assessing the validity of the canonical loadings. Column 3, 4, 5, 6, 7, 8, 9, 10 in Table V depicts the results of stability runs after deletion of independent variables (X1–X8).

6. Effect of agile manufacturing implementation period on manufacturing performance improvements

Further, to examine the effect of agile manufacturing implementation period on business performance enhancements, the respondent data have been classified into three phases depending upon the period of agile manufacturing implementation (Jain and Ahuja, 2012; Randhawa and Ahuja, 2018) (Table VI).

The objective of ANOVA is to examine the significance of the difference among more than two sample means at the same time to test the null hypothesis that all group means are equal. We should test different assumptions of ANOVA (Field, 2005), before applying ANOVA. The first is the variable data should be normally distributed. If the “Sig.” value is > 0.05, then data are said to be normally distributed, but if the value of “Sig.” is < 0.05, then data is not normally distributed. The Shapiro–Wilk test is used to check normal distribution of data (Table VII). The results portray that normality is violated in most of the cases.

Table VI. Classification of the respondent data based upon agile manufacturing implementation period

Phases	Organization’s experience in agile manufacturing implementation	Number of responses (n)
Phase 1-introductory phase	Less than or equal to three years	9
Phase 2-stabilization phase	More than three years to five years	64
Phase 3-maturity phase	More than five years	81

Table VII. Shapiro–Wilk test for normality

Performance parameters	Phase 1			Phase 2			Phase 3		
	Statistics	*df*	Sig.	Statistics	*df*	Sig.	Statistics	*df*	Sig.
Y1	0.97	9.00	0.91	0.87	64.00	0.00	0.73	81.00	0.00
Y2	0.92	9.00	0.42	0.96	64.00	0.05	0.92	81.00	0.00
Y3	0.92	9.00	0.37	0.94	64.00	0.01	0.76	81.00	0.00
Y4	0.88	9.00	0.17	0.87	64.00	0.00	0.69	81.00	0.00
Y5	0.89	9.00	0.21	0.91	64.00	0.00	0.75	81.00	0.00
Y6	0.85	9.00	0.07	0.91	64.00	0.00	0.79	81.00	0.00

Notes: Customer-related achievements (Y1), financial achievements (Y2), business-related achievements (Y3), operational achievements (Y4), employee-related achievements (Y5), supplier-related achievements (Y6)

The second assumption is the assumption of homogeneity of variance. Levene's test is the most widely used test to check the assumption of homogeneity of variance (Verma and Sharma, 2019). When the value of "Sig." is > 0.05, then it is assumed to have equal variance and met the condition of homogeneity of variance. But if the "Sig." value is lower than 0.05, then it is assumed to have unequal variance and violate the condition of homogeneity of variance. The results of Levene's test (Table VIII) depicts the considered parameters does not meet the assumption of homogeneity of variance.

When normality of data is violated, population variance is unequal and sample size is also unequal, in that case Welch's test is used for performing an ANOVA analysis (Verma and Sharma, 2019). Table IX portrays the results for robust test for equality of means. Considering the value of significance level, we can conclude that it supports one-way ANOVA results.

As the data satisfy all the assumptions of ANOVA, next step is to select the appropriate post-hoc test. If the F-value is greater than 1, then the difference between group means is existent (Field, 2005), shown in Table X. From Table X, we can conclude that all phases are significantly different for all constructs as the p-value is less than 0.05. The ANOVA $F_{calculated}$ values for various constructs are significantly greater than F_{table} value of 2.99 for α level $= 0.05$, $df1 = 2$, $df2 = 151$ or F_{table} value of 4.61 for α level $= 0.01$, $df1 = 2$, $df2 = 151$, thereby rejecting the null hypothesis, which means reasonably high difference among the means of three groups (phases).

The "Games–Howell" post-hoc test is the most appropriate test for multiple comparisons to find out statistical significance of difference of means between various phases if the homogeneity of variance assumption is violated (Verma and Sharma, 2019). Each phase is compared to all of the remaining phases. For each pair of phases, the difference between their means, the standard error of that difference and significance level of that difference is displayed in Table XI. The significance values of $p < 0.001$ during the examination of mean difference in Games–Howell test for enhancements in performance parameter achieved in

	Test of homogeneity of variance, $df1 = 2$, $df2 = 151$		
Performance parameters	Levene's statistic	Sig.	Variance
Y1	19.240	0.000	Unequal variance
Y2	6.947	0.001	Unequal variance
Y3	11.392	0.000	Unequal variance
Y4	16.842	0.000	Unequal variance
Y5	13.792	0.000	Unequal variance
Y6	13.358	0.000	Unequal variance

Notes: Customer-related achievements (Y1), financial achievements (Y2), business-related achievements (Y3), operational achievements (Y4), employee-related achievements (Y5), supplier-related achievements (Y6)

Table VIII.
Levene's test for equality of variance

		Robust test for equality of means			
Performance parameters		Statistic[a]	df1	df2	Sig.
Y1	Welch	56.789	2	19.832	0.000
Y2	Welch	19.441	2	20.618	0.000
Y3	Welch	92.957	2	20.356	0.000
Y4	Welch	86.955	2	19.708	0.000
Y5	Welch	72.464	2	19.958	0.000
Y6	Welch	62.194	2	20.085	0.000

Note: [a]Asymptotically F distributed

Table IX.
Robust test for equality of means

Constructs	Sum of squares	df	Mean^2	F	Sig.
Customer-related achievements (Y1)					
Between groups	29.761	2	14.881	104.051	0.000
Within groups	21.595	151	0.143		
Total	51.357	153			
Financial achievements (Y2)					
Between groups	16.100	2	8.050	34.757	0.000
Within groups	34.973	151	0.232		
Total	51.074	153			
Business-related achievements (Y3)					
Between groups	39.115	2	19.557	141.634	0.000
Within groups	20.851	151	0.138		
Total	59.965	153			
Operational achievements (Y4)					
Between groups	48.994	2	24.497	131.452	0.000
Within groups	28.140	151	0.186		
Total	77.134	153			
Employee-related achievements (Y5)					
Between groups	42.610	2	21.305	110.940	0.000
Within groups	28.998	151	0.192		
Total	71.609	153			
Supplier-related achievements (Y6)					
Between groups	39.484	2	19.742	102.464	0.000
Within groups	29.093	151	0.193		
Total	68.577	153			

Table X. ANOVA table

phase 2 and 3 *vis-à-vis* those in phase 1 clearly reveal that mean difference has been statistically significant. Similarly, for phase 3 *vis-à-vis* phases 2 and 1 have been statistically significant with $p < 0.001$, indicating that the manufacturing industry have successfully reaped enhancement in business performance in stabilization and maturity phases *vis-à-vis* introductory phase. Thus, *H3*: implementation period has a significant role in successful implementation of agile manufacturing holds true.

7. Discriminant validity test for classifying highly successful and moderately successful organizations

Finally, the discriminant validity test has been conducted to classify highly successful and moderately successful companies based on predictor variables of manufacturing achievements accrued by successful implementation of agile manufacturing in the organizations. Discriminant analysis is deployed to determine the probability of categorical group membership using predictor variables. The discriminant validity test has been conducted in the present study to successfully predict the success level of the companies based on performance parameters, namely customer-related achievements (Y1), financial achievements (Y2), business-related achievements (Y3), operational achievements (Y4), employee-related achievements (Y5), supplier-related achievements (Y6), obtained through "agile manufacturing questionnaire," whereas the categorical output variable is the status of agile manufacturing practices, which has further been classified into "0 – moderate success" and "1 – high gain." The discriminant analysis "group statistics" data clearly indicate that pre-test means of "high gain" organizations are higher than those of "moderate success" organizations as shown Table XII. The "tests of equality of group means" depicts that

Performance parameters	Multiple comparisons Games–Howell I	J	Mean difference (I–J)	SE	Sig.
Customer-related achievements (Y1)	Phase 1	Phase 2	−1.45862*	0.21028	0.000
		Phase 3	−1.86008*	0.20252	0.000
	Phase 2	Phase 1	1.45862*	0.21028	0.000
		Phase 3	−0.40146*	0.06558	0.000
	Phase 3	Phase 1	1.86008*	0.20252	0.000
		Phase 2	0.40146*	0.06558	0.000
Financial achievements (Y2)	Phase 1	Phase 2	−0.93368*	0.29472	0.029
		Phase 3	−1.30864*	0.29191	0.005
	Phase 2	Phase 1	0.93368*	0.29472	0.029
		Phase 3	−0.37496*	0.07680	0.000
	Phase 3	Phase 1	1.30864*	0.29191	0.005
		Phase 2	0.37496*	0.07680	0.000
Business-related achievements (Y3)	Phase 1	Phase 2	−1.37630*	0.19792	0.000
		Phase 3	−2.00000*	0.19205	0.000
	Phase 2	Phase 1	1.37630*	0.19792	0.000
		Phase 3	−0.62370*	0.06330	0.000
	Phase 3	Phase 1	2.00000*	0.19205	0.000
		Phase 2	0.62370*	0.06330	0.000
Operational achievements (Y4)	Phase 1	Phase 2	−1.32951*	0.25917	0.001
		Phase 3	−2.12099*	0.25098	0.000
	Phase 2	Phase 1	1.32951*	0.25917	0.001
		Phase 3	−0.79147*	0.07398	0.000
	Phase 3	Phase 1	2.12099*	0.25098	0.000
		Phase 2	0.79147*	0.07398	0.000
Employee-related achievements (Y5)	Phase 1	Phase 2	−1.43924*	0.23703	0.000
		Phase 3	−2.08889*	0.22817	0.000
	Phase 2	Phase 1	1.43924*	0.23703	0.000
		Phase 3	−0.64965*	0.07599	0.000
	Phase 3	Phase 1	2.08889*	0.22817	0.000
		Phase 2	0.64965*	0.07599	0.000
Supplier-related achievements (Y6)	Phase 1	Phase 2	−1.46224*	0.24537	0.000
		Phase 3	−2.04938*	0.23777	0.000
	Phase 2	Phase 1	1.46224*	0.24537	0.000
		Phase 3	−0.58714*	0.07503	0.000
	Phase 3	Phase 1	2.04938*	0.23777	0.000
		Phase 2	0.58714*	0.07503	0.000

Table XI.
Post-hoc analysis

Performance parameters	Status Moderate success	High gain	Total
Y1	0.6715	0.9377	0.8928
Y2	0.6154	0.8137	0.7802
Y3	0.6031	0.9057	0.8546
Y4	0.5769	0.8992	0.8448
Y5	0.5673	0.9031	0.8464
Y6	0.5758	0.8927	0.8392

Table XII.
Mean of success of organizations

Wilks' λ is statistically significant for each of the predictor variables, which is ideal in this case, that all the six results are significant as shown in Table XIII.

The Box's test for equality of covariance matrices depicted in Table XIV, reveals that log determinants for "moderate success," "high gain" and "pooled within-groups" segments are pretty similar at "−24.142," "−30.987" and "−28.855," respectively, which is acceptable. Also the test reveals high Box's *M* value of 152.935 significant at level $p < 0.001$. Here, it should be noted that Box's *M* significance level should be < 0.001, unlike other statistical tests, whereas the significance level of < 0.05 is usually acceptable. Thus, in the present case, the significance level is < 0.001, thus the null hypothesis of equal covariance matrix assumption is rejected and thus there is a significant difference in the covariance of two subgroups.

Further, the examination of canonical discriminant functions depicts that a large eigenvalue (1.535) explains the variance of the function in the outcome variable appropriately and the canonical correlation works out to be 0.858. The Wilks' λ predicts how well the prediction model fits. In this case, the prediction model is statistically significant (< 0.001), as depicted from Table XV.

The standardized canonical discriminant function coefficients are further evaluated to assess the contributions of the individual predictor variables in the outcome variable. Table XVI reveals that predictor variable is the predominant variable with canonical discriminant function coefficient 0.436, followed by Y3 (0.290) and Y1 (0.252). Similarly, the structure matrix also provides the consistency between these two tables with a similar pattern of results. Also, it is observed that the lowest value of a function in the structure matrix is 0.486, which is > 0.3, which is the minimum accepted value. Finally, the classification statistics data reveal that this model accurately classifies 92.2 percent of original grouped cases and 90.9 percent of cross-validated cases as depicted in Table XVII. Further, Table XVII reveals that, 97.7 percent organizations are reporting "High success,"

	Wilks' λ	*F*	df1	df2	Sig.
Y1	0.522	139.346	1	152	0.000
Y2	0.734	55.135	1	152	0.000
Y3	0.472	169.759	1	152	0.000
Y4	0.534	132.451	1	152	0.000
Y5	0.455	181.723	1	152	0.000
Y6	0.495	154.864	1	152	0.000

Table XIII. Tests of equality of group means

	Log determinants		Test results		
Status	Rank	Log determinant	Box's *M*		152.935
Moderate success	6	−24.142	*F*	Approx.	6.625
High success	6	−30.987		df1	21
Pooled within-groups	6	−28.855		df2	7,338.600
				Sig.	0.000

The ranks and natural logarithms of determinants printed are those of the group covariance matrices.

Tests null hypothesis of equal population covariance matrices.

Table XIV. Box's test of equality of covariance matrices

		Eigenvalues		
Function	Eigenvalue	% of variance	Cumulative %	Canonical correlation
1	1.535[a]	100.0	100.0	0.778
		Wilks' λ		
Test of function(s)	Wilks' lambda	χ^2	df	Sig.
1	0.394	138.605	6	0.000

Note: [a]First 1 canonical discriminant functions were used in the analysis

Table XV. Summary of canonical discriminant functions thus revealing high sensitivity of 97.7 percent, whereas for "moderate gain" organizations, 65.4 percent organizations have been categorized as "moderate success." Thus, *H4*: agile manufacturing implementation has a high success rate holds true.

8. Conclusion

As market situation has become highly turbulent and competitive, agile manufacturing has emerged as a most critical success factor to sustain in hypercompetitive business environment, as it enables manufacturer to be more market sensitive, synchronize itself with unpredictable demand of customers and foster customer satisfaction. In current business environment, customers expect their manufacturer to adopt innovation and agility to provide various financial and non-financial benefits. The enterprises who adopt the concept of agile manufacturing, have the ability to rapidly and efficiently respond to customer's demand, flawless production of products with superior quality, which not only satisfies the customer but also delight customer. Maintaining an agile organization culture is a key success element for the manufacturing sector and can only be attained by efficient implementation of agile manufacturing. The present work highlights the contribution of various agile manufacturing initiatives in Indian manufacturing industry in achieving the strategic benefits for meeting the challenges imposed by the hypercompetitive global business environment. Various statistical tools have been employed in

Table XVI. Standardized canonical discriminant function coefficients and structure matrix

Standardized canonical discriminant function coefficients	Function	Structure matrix[a]	Function
	1		1
Y1	0.252	Y5	0.882
Y2	0.059	Y3	0.853
Y3	0.290	Y6	0.815
Y4	−0.036	Y1	0.773
Y5	0.436	Y4	0.753
Y6	0.210	Y2	0.486

Notes: Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions. Variables ordered by absolute size of correlation within function

Table XVII. Classification results[a,c]

Status	Moderate success	High gain	Total
Orginal			
Count			
Moderate sucess	17	9	26
High success	3	125	128
%			
Moderate success	65.4	34.6	100.0
High success	2.3	97.7	100.0
Cross-validated[b]			
Count			
High success	15	11	26
Moderate success	3	125	128
%			
Moderate success	57.7	42.3	100.0
High success	2.3	97.7	100.0

Notes: [a]92.2 percent of original grouped cases correctly classified. [b]cross-validation is done only for those cases in the analysis; in cross-validation, each case is classified by the functions derived from all cases other than that case. [c]90.9 percent of cross-validated grouped cases correctly classified the present study to examine the role of agile manufacturing success factors in reaping enhancements in business performance in Indian manufacturing industry. Empirical evidence has been reported to justify the relationship among agile manufacturing success factors and business performance improvement indicators. The present work portrays that successful deployment of agile manufacturing initiatives is a critical and significant factor toward realization of overall organizational growth through customer-related achievements, financial achievements, business-related achievements, operational achievements, employee-related achievements and supplier-related achievements. The present study acknowledged that agile manufacturing success factors, namely, leadership support, information technology and human resource management, have a significant role in accomplishing continuous improvement in business performance in manufacturing industry to sustain in the highly progressive global economy.

Top management support is one of the most prominent factors in successfully implementing agile manufacturing. Top management commitment and support foster the innovations, thereby creating superior value for customers within economical and ethical constraints. The importance of information technology to enhance performance has been widely recognized in literature. There is a strong need to develop a consistent socio-technical system between human resource management practices, and technological and manufacturing practices to enhance overall performance of the organization. Supplier management is a vital ingredient in agile manufacturing. Agile manufacturing practices have experienced a transformation from many arms-length relationships to more collaborative supplier relationship. The dynamic business atmosphere, advancements in technologies and ever-changing customer needs are expected to introduce both opportunities and threats for the manufacturing sector. Further, the study validates continuous improvements in competitive dimensions results achieved through successful implementation of agile manufacturing over extended time periods, thereby indicating that agile manufacturing has the capability of yielding progressive improvements in competitive dimensions over long time periods and these programs must not be adopted for shorter durations.

The present work delivers useful implications for both academicians and managers in the industry. The results of this study can prompt manufacturing industry to realize the significance of agile manufacturing implementation, as it is evident that agile manufacturing has the capability to improve the competitive dimensions for survival and growth of the organizations. It can help senior management to formulate business strategies so that they will be able to make better and effective decisions about agile manufacturing implementation in their organization.

9. Research limitation and future directions

Like any other study, the results of this work are subjected to several limitations. First, this research work is carried out particularly in the manufacturing sector, thus, the findings cannot be generalized for other sectors. Future investigation may concentrate on other sectors also. Second, the current study is conducted in India, a developing country, in which the business environment differs from that of the developed nations. Hence, the results obtained from this study will need some modification before applying to other geographical locations.

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