Development of a framework for agile manufacturing

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Abstract

Purpose – In the past, the insufficiency of the traditional business practices to meet vibrant customer demands in continuously changing business environment has severely affected organizational competitiveness. The purpose of this paper is to develop and propose a new framework for smoother and effective implementation of agile manufacturing by identifying and integrating a set of significant agility principles and techniques.

Design/methodology/approach – The present work proposed a framework for agile manufacturing by deploying the comparative analysis of 17 frameworks published in peer-reviewed journals.

Findings – The proposed conceptual framework constitutes of eight pillars for agile manufacturing implementation. The proposed framework relies on a strong foundation of leadership support. The roof of the proposed framework of agile manufacturing is supported by the pillars constituted of seven elements, an industry must deploy for successfully implementing agile manufacturing, namely, human resource-related issues, organizational culture-related issues, supplier-related issues, customer-related issues, innovation, concurrent engineering and information technology.

Originality/value – This work is the first attempt, in the best knowledge of the authors, to employ comparative analysis for critically analyzing a wide range of agile manufacturing frameworks. The findings of this study will assist researchers and managers in agile manufacturing implementation in more a smoother and effective way in manufacturing industries.

Keywords Agile manufacturing, Business performance, Manufacturing industry

Paper type Literature review

1. Introduction

Globalization has intensified the competition among manufacturers 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). This situation has motivated 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). Agility in an organizational structure is indispensable requirement for success and competitive advantage (Vazquez-Bustelo *et al.*, 2007). The hypercompetitive business environment encourages a 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; Mukherjee *et al.*, 2015; Potdar *et al.*, 2017a). Agile manufacturing generates numerous benefits for manufacturing organizations (Hormozi, 2001). Agile manufacturing positively impacts organizational performance in cost, quality, delivery and flexibility, 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, 2019). Organizational agile capabilities play a considerable role in new product development

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(Leite and Braz, 2016). Successful implementation of agile manufacturing builds cooperation to enhance competitiveness (Gunasekaran, 1999; Sharifi and Zhang, 1999; Hormozi, 2001; Giachetti *et al.*, 2003), change in organizational culture to master change and uncertainty (Gunasekaran, 1999; Sharifi and Zhang, 1999; Giachetti *et al.*, 2003; Ren *et al.*, 2003; Raj *et al.*, 2014), empowerment of employee (Gunasekaran, 1999; Meade and Sarkis, 1999; Breu *et al.*, 2002; Gore *et al.*, 2009) and foster customer enrichment (Meade and Sarkis, 1999; Ren *et al.*, 2003; Raj *et al.*, 2014; Dubey and Gunasekaran, 2015). Gunasekaran *et al.* (2018) discussed about five enablers of agile manufacturing, i.e. "transparent customization," "agile supply chains," "intelligent automation," "total employee empowerment" and "technology integration." 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. Agility acquisition has become increasingly important for manufacturing organizations and is proven as a profit-generating element in modern day business environment. Agile manufacturing has found new vigor and purpose to increase customer satisfaction and business performance due to increasing emphasis on sustainability (Vazquez-Bustelo *et al.*, 2007). Agile manufacturing is emerging as an imperative strategy for enterprises and its impact on business performance is appreciated in all industrial sectors. The technological advancements over the last decade have had a significant effect on manufacturing industry around the world (Phang and Foong, 2010). 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. After the Second World War, cost effectiveness and delivery time were the over-riding manufacturing factors due to the incompetence of the manufacturing sector in meeting the high demand resulting in mass production, incorporating high automation of manufacturing system. Mass production systems produced a 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 earlier 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. The industrial sector has been forced to attain more flexibility, retaining optimum quality and minimum cost. The enterprises that 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 that not only satisfies the customer but also delight customer. Earlier, the success of a manufacturing firm could be quantified by its cost effectiveness in producing a single product, 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.

2. Literature review

The concept of agile manufacturing has emerged as a global phenomenon to compete and sustain in business environment turmoil. Agile manufacturing integrates strategies, available technology and human resources to provide customer-driven products and

services by beating business environment uncertainties. Over the years, many researchers have put in numerous efforts in the field of assessment and implementation of agile manufacturing through proposing various frameworks. 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). 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 AM environment. Vazquez-Bustelo *et al.* (2007) found that AM application has boosted the operational, market and financial performance of the firm, simultaneously promoting competitive manufacturing strength. Inman *et al.* (2011) investigated the linkage among Just-in-time, agile manufacturing, operational performance and firm performance.

Pantouvakis and Bouranta (2017) proposed a theoretical framework linking organizational learning culture to customer relationship quality, through agility and investigated that 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. Nabass and Abdallah (2019) 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.

3. Research methodology

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. 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 to gain advantage of opportunities in the market in order to satisfy individual customer preferences. There are a number of drivers that drive the need to implement agile manufacturing, i.e. automation, cost consideration, customer choice and expectation, competing priorities and very frequent innovation. The present work has searched articles on agile manufacturing from various online databases, but only those articles are shortlisted those proposed any kind of framework and are empirical studies. The time horizon considered for the current study is 29 years, starting from 1990 to 2018. We would like to mention that 2018 is selected as the end-point to collect the research papers, but we did not find any framework during the year 2018. The study has focused on 17 research articles (Table I) published in 15 journals (Table II). The present work would like to mention that the considered frameworks are not a standard list of agile manufacturing frameworks and do not represent a complete set of agile manufacturing frameworks.

S. No.	Frameworks
1	Gunasekaran (1998)
2	Sharp *et al.* (1999)
3	Ren *et al.* (2003)
4	Vazquez-Bustelo *et al.* (2007)
5	Hasan *et al.* (2009)
6	Eshlaghy *et al.* (2010)
7	AL-Tahat and Bataineh (2012)
8	Saleeshya and Babu (2012)
9	Mishra *et al.* (2013)
10	Raj and Vinodh (2014)
11	Dubey and Gunasekaran (2015)
12	Routroy *et al.* (2015)
13	Samantra *et al.* (2015)
14	Leite and Braz (2016)
15	Sindhwani and Malhotra (2016)
16	Kumar *et al.* (2017)
17	Sindhwani and Malhotra (2017)

Table I.
Frameworks of agile manufacturing

Journal name	No. of articles
International Journal of Production Research	2
International Journal of Industrial and Systems Engineering	2
Benchmarking: An International Journal	1
International Journal of Production Economics	1
Integrated Manufacturing System	1
International Journal of Operations and Production Management	1
International Journal of Business and System Research	1
International Journal of Logistics Systems and Management	1
Journal of Engineering, Design and Technology	1
International Journal of Advanced Manufacturing Technology	1
Journal of Manufacturing Technology Management	1
International Journal of Process Management and Benchmarking	1
International Journal of System Assurance Engineering and Management	1
Mathematical Problems in Engineering	1
Measuring Business Excellence	1

Table II.
List of journals with number of selected articles for review

4. Comparative analysis of agile manufacturing elements

The present study has employed comparative analysis to identify and list the unique elements from shortlisted articles on agile manufacturing. It is imperative to develop a deep understanding of existing frameworks, the issues addressed so far in the agile manufacturing literature and the issues yet to be addressed, to build a new framework. Figure 1 depicts the comparative analysis and the frequency of occurrence of these elements, but due to space constraints, only a few elements are listed to give a brief overview of the structure of the table. Figure 1 portrays in the first column, the elements considered under different frameworks and the first row depicts the various frameworks considered for the present study. The 17 frameworks were identified from an extensive literature review and had around 237 constructs of agile manufacturing. These constructs depict the enablers for the successful implementation of agile manufacturing. The present work shows that many constructs are repeated in more than one framework and similar constructs appear in different forms in various frameworks. Therefore, the constructs with similar meanings are

Articles ---------->								
Elements	1	2	3	----------	16	17	Frequency	Weightage
Information technology				----------			17	1.00
Organizational culture				----------			15	0.88
Human resource							14	0.82

Multi-media				----------			1	0.06
Seasonality				----------			1	0.06
Product variety				----------			1	0.06

Figure 1.
Brief summary of comparative analysis of existing framework

clubbed together. It can be noticed from the comparative analysis that certain constructs had a frequency of 0.2 or more. That is, 20 percent or more of framework were giving importance to these constructs. Hence, those constructs were considered critical for agile manufacturing and called "pillars" of agile manufacturing framework.

5. A conceptual framework of agile manufacturing

5.1 Foundation of the framework

It is imperative to seek "Leadership support" because it is one of the most prominent factors in successfully implementing agile manufacturing. Merely adopting certain prescribed tools and techniques do not make an organization agile, management must have an agile mindset to be agile organization. Top management support helps in building an internal alliance, which is necessary for developing agile manufacturing systems.

5.2 Pillars of framework

The roof of proposed framework of agile manufacturing is supported by the pillars constituted of seven elements, an industry must deploy for successfully implementing agile manufacturing, namely, human resource-related issues, organizational culture-related issues, supplier-related issues, customer-related issues, innovation, concurrent engineering and information technology. The following list portrays the pillars of the framework for agile manufacturing:

(1) leadership support;

(2) human resource-related issues;

(3) organizational culture-related issues;

(4) supplier-related issues;

(5) customer-related issues;

(6) innovation;
(7) concurrent engineering; and
(8) information technology.

5.3 Roof of the framework

The top end of the pillars depicts the performance indicators (Gunasekaran, 1999; Cao and Dowlatshahi, 2005; Adeleye and Yusuf, 2006; Vazquez-Bustelo *et al.*, 2007; Gore *et al.*, 2009; Potdar and Routroy, 2017), which can be achieved by successfully deploying the agile tools and techniques to attain overall business excellence. The roof of proposed framework is agile manufacturing that improves the overall organizational business performance of the company.

5.4 Salient features of the proposed agile manufacturing framework

Following are some of salient features of the proposed framework of agile manufacturing:

- The present study has shortlisted 17 articles through an extensive literature review to propose eight pillars of proposed framework of agile manufacturing.
- The proposed framework relies on a strong foundation of leadership support.
- The roof of proposed framework of agile manufacturing is supported by the pillars constituted of seven elements an industry must deploy for successfully implementing agile manufacturing, namely, human resource-related issues, organizational culture-related issues, supplier-related issues, customer-related issues, innovation, concurrent engineering and information technology.
- The top end of the pillars depicts the performance indicators, which can be achieved by successfully deploying the agile tools and techniques to attain overall business excellence. The roof of proposed framework is agile manufacturing that improves the overall organizational business performance of the company.
- The proposed framework highlights the thrust area to be focused and lays down the pathway to be followed to become an agile manufacturer (Figure 2).

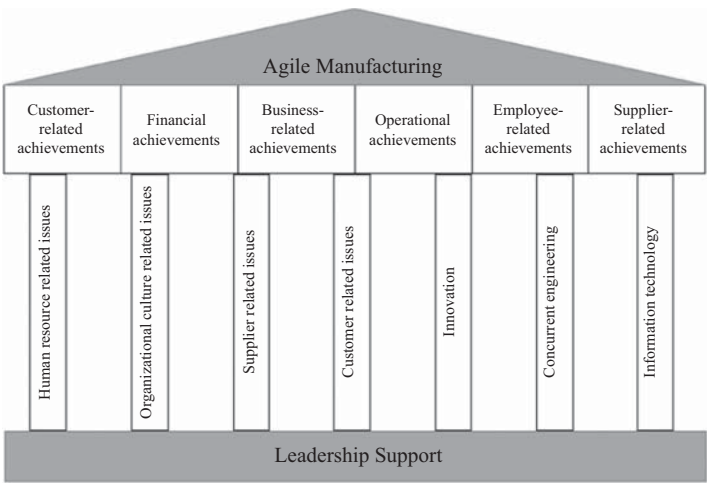

Figure 2.
Proposed framework for agile manufacturing

6. Conclusion

The present work initially highlighted the challenges that encourage the manufacturing sector to implement agile manufacturing. As market situations have become highly turbulent and competitive, agile manufacturing has emerged as a most critical success factor to sustain in hypercompetitive business environment, as it enables a manufacturer to be more market sensitive, synchronize itself with unpredictable demand of customers and foster customer satisfaction. In current business environment, customers expect their manufacturers to adopt innovation and agility to provide various financial and non-financial benefits. 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 current work reviewed 17 research articles published in various peer-reviewed journals. The primary objective of this work was to carry comparative analysis of the shortlisted research articles on agile manufacturing to propose a framework for agile manufacturing. Thus, 237 constructs from 17 articles were critically examined and constructs with similar meaning were clubbed together. The constructs with frequency of 0.2 or more are considered as "pillars" of agile manufacturing framework. The present work delivers useful implications for both academicians and managers in the industry.

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