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Research paper

The Mediating Role of Overall Equipment Effectiveness on the Relationship between Fit Manufacturing and Business Performance

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Abstract

Advanced manufacturing technology systems have replaced traditional manufacturing systems as manufacturing industry have many technological developments in recent years. Now, the primarily concern is effectiveness of the equipment for the modern manufacturing technology systems. Though, there is a lack of empirical studies confirming this impact on business performance. Recently, manufacturing industries have adapted fit manufacturing strategies in order to enhance the system effectiveness to get competitive advantage. These strategies are mainly, lean, agile and sustainable manufacturing. This paper aims to systematically review the literature on the existing fit manufacturing strategies and their relationship with business performance from year 2009 to 2015, also to find the possible intervening variable that can influence the inconsistency of the relationships between the fit manufacturing strategies and business performance. On the basis of the findings from the systematic literature review, we suggest researchers on the in the field of operations management to investigate the mediating relationship of overall equipment effectiveness between the relationship of the fit manufacturing strategies and business performance.

Keywords: *Fit manufacturing; Lean, Agile; Business performance.*

1. Introduction

Acceleration of economic growth has some major constituents and manufacturing sector is one of those. Manufacturing systems are affected by current advancements in technology and globalization. Lean manufacturing and agile manufacturing are two comprehensive manufacturing systems, the focus of manufacturing sector. Nevertheless, to incorporate within manufacturing process, the environmental and social factor, manufacturing sector is under pressure from policy makers and society along with customers. These stakeholders want to guard society and environment from harmful effect of the process of manufacturing [1-3]. As a result, a sustainable manufacturing system has been adapted. Though, increase effectiveness of manufacturing through enhancing process effectiveness and cost reduction is the drive behind these manufacturing systems. Thus, manufacturing strategies that focused on the finding strategic fit between production cost and performance can be considered as the fit manufacturing strategies. Literature exposed the relationship of fit manufacturing strategies with business performance. However, this relationship is inconsistent in terms of applications of the different strategies in different context. This indicates the existence of some intervening factors that affects the relationship of the fit manufacturing and business performance. For this reason, the current study aims to investigate the factor that can mediate the relationship between fit manufacturing strategies and business performance. the analysis and evaluate the core competency requirements of the factory, thus focusing on determining the new core competencies needed to manage along with extending the fit manufacturing. Therefore, firms persist beyond lean as well as doing new levels of improved business performance. This comprises analysing technological, managerial together with manufacturing competencies that in turn will determine new skills in addition to using the knowledge-based agenda in the future [4]. Most studies have indicated that globalization, changeable markets, improved product customization and competitive advantage present many challenges to manufacturing firms, both currently and in the future.

2. Literature Review

This section presents literature review on fit manufacturing. The literature is systematically reviewed from 2009 up to 2015. For the current systematic literature review, the researcher used specific keywords for searching. These keywords are mainly fit manufacturing and business performance, agile manufacturing and business performance, lean manufacturing and business performance, sustainable manufacturing and business performance in general. The web of science, Scopus databases were used to conduct the systematic literature review. Once articles were extracted, the

researcher matched the scope of the article with the current study before inclusion of the article in the review process. Out of 81 extracted articles only 21 articles were included in the systematic review based on the inclusion and exclusion criteria defined by the researcher. The details are provided in Table 1.

Table 1: Inclusion and exclusion of the papers from Systematic review

Database	Number of Articles extracted	Papers Rejected after scrutiny	Paper accepted to be included in systematic review
Web of science	39	27	12
Scopus	25	17	8
Others	17	16	1
Total	81	60	21

2.1 Fit Manufacturing Strategies

A study by Williams [5] revealed that fit manufacturing is a company-wide approach, supporting governances to oversee problems in the marketplace, such as customer suppositions in relation to production. Fit manufacturing can assist administrations through continuing agility and sustainability. Furthermore, Pham, Thomas [6] revealed that fit manufacturing comprises of a number of combined activities, such as manufacturing, marketing, and product innovation strategies, which lead to the achievement of economic sustainability.

Vinodh, et al. [2014] also revealed that fit manufacturing is a competitive manufacturing model, which involves lean and agile manufacturing and its sustainable benefits. Fit manufacturing system can be considered as an integrated approach, which involves lean manufacturing, agile manufacturing, and sustainability[8]. According to [9], to meet competition of global market and become sustainable, manufacturing organizations are assisted by fit manufacturing framework.

Generally, it has been noticed by researcher that fitness production or fit manufacturing performs as a new strategy. Lean manufacturing, sustainability and agile manufacturing are the three elements of this strategy. This strategy is not only considered fit manufacturing, but the other sector of management like operations, marketing, and sales are also connected through it. This gives the organization a competitive advantage in all of the domains.

Past research explains fit manufacturing in various ways including complete fit manufacturing constructs. The literature review is based on past studies and a review of fit manufacturing literatures. The experimental study has been entirely analysed by [4, 8-18]

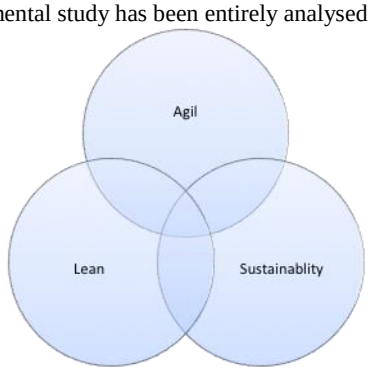

Fig. 1: Fit Manufacturing

2.2 Overall Equipment Effectiveness [OEE]

The concept of total productive maintenance [TPM], which was launched by Nakajima [19] in the 1980s, provided a quantitative metric known as Overall Equipment Effectiveness [OEE] which has been used for measuring productivity of individual equipment in a factory. It identifies and as well it measures losses of crucial aspects of the manufacturing processes which include availability, performance and quality rate. This supports the improvement of equipment effectiveness as well as its productivity. In Japan, the concept of TPM was formulated from practical experiences in several Japanese enterprises by JIPM during the 1970s. The TPM which is originally a concept for corporate change now includes a way of also defining overall equipment effectiveness [OEE]. This definition of OEE by TPM includes both downtime as well as other production losses which negatively affect throughput. Three dimensions of effectiveness are considered and these are availability; performance rate and quality rate [20].

Metrics both for measuring as well as for analysing the productivity of manufacturing facilities has being the focus of several studies for many decades. Unfortunately, the conventional metrics for measuring productivity are limited to throughput and utilization rate, which measure only a part of the performance of manufacturing equipment. This tool may not be very helpful for identifying challenging problems as well as underlying improvements essential for increase in productivity. Owing to intense global competition, companies are striving relentlessly to improve and optimize their productivity in order to sustain competitiveness. This situation has led to the increasing thrust for more rigorous definition of productivity metrics that are capable of taking into account several crucial factors such as equipment availability [including breakdowns, set-ups and adjustments], performance [reduced speed, idling and minor stoppages], and quality [defects, rework and yield] as previously documented [21].

It was mentioned that to stay competitive, productive facilities are must for manufacturing companies [22]. Organizations endeavour for different ways in tough global competition by optimizing and improving their production to gain competitive advantage [21]. A good strategy to achieving this is by reducing costs which can be made possible by elimination of the unnecessary production losses by their identification thus the need for measurement of the performance of manufacturing process production effectively. [23] proposed a tool to quantity a factory's individual equipment's productivity as [OEE] formally known as Overall Equipment Effectiveness.

It measures different kinds of production losses along with illustration areas for process improvement and is defined as performance measurement tool [24]. [25] defined Overall Equipment Effectiveness as "the primary metric of Total Productive Maintenance. It indicates a single piece of equipment's actual contribution as a percentage of its potential to add value to the value stream " [p. 66]. [26], discloses it as a helpful measurement tool for equipment losses. Overall Equipment Effectiveness tool measures a single machine's effectiveness.

Based on this review, to identify causes of production losses, it can be observed that OEE is a cherished measure. Performance optimization of the existing capacity is manageable with OEE. Moreover, reduction in the expenditure of overtime, deferment of investments of larger capital, reduction in process of variability and in changeover time, reduction in changeover times and improvement in the performance of the operator are the benefits of OEE. An organization can maintain its competitive edge and can increase its operations of production through the OEE benefits, as aforementioned. Quality rate, performance and availability are the the significantly highlighted areas where OEE can identify and gauge losses of manufacturing [27].Stamatis [28] has explained a number of contributions of OEE which include Improve productivity, Reduction cost and Raise awareness, Machine productivity, and Increase in life of equipment. The effects of these objectives are to reduce cost, increase in profits, maintain a distinguish ownership of equipment.

2.3 Relating Fit Manufacturing Strategies With Business Performance

Over the years, researchers have reported different fit manufacturing strategies that affect the business performance. For example, [12] found a positive correlation between fit manufacturing and performance. [29] found the relationship between lean manufacturing practices, environmental management and business performance outcomes. Similarly, [30] reported the relationship of sustainable manufacturing with business performance. A positive and direct relationship was found between lean manufacturing and operational performance. Another study found that agile manufac-

turing has a direct positive association with the operational performance. [31]found a positive direct influence sustainable improvement methods and firm performance. Some environmental along with social improvement practices have a positive direct correlation with the product as well as process innovation. Moreover, This study conclusion that better collaboration together with suppliers on ecological work can help to increase the green capabilities of the organization. [32] found that the financial performance indexes are correlated with non-financial performance indexes like employees' satisfaction. This study also found that should measure the impact of finance-social capabilities [constraints] both financing strategies and non-financial performance indexes related to sustainability performance [36-39].
[33]imply that there are advantages obtained by realizing a fit system, as it actively supports knowledge and skills arrangement. Technology will become necessary during a firm's improvement, to provide the firm's workforce with fitting skills to the worker. The fit system supports continuous improvement through innovation by introducing new, creative products to make the market more modern. Moreover, the firm should compel its workers to participate in training courses. Therefore, this change combines modern knowledge with an understanding of the technology needed to support the next stage of the firm's improvement.
According to[14] in his idea of new manufacturing strategy mentioned that 'Fit' itself has several meanings as an adjective, verb and noun. As an adjective, Fit means: [i] a thing of a suitable quality, standard, or type to meet the required purpose, [ii] to be in good health, especially because of regular physical exercise. Fit as a verb means: [i] to be the right shape and size to meet a need, [ii] to put something into place and [iii] to be in agreement or harmony with something".
It is observed that Fit manufacturing is an organizational strategy which handles complications of market place and expectations of consumers in terms of prices and products, process waste elimination, supply chain management, production capacities adaption for new products designs, and fluctuations of market. Organizations can remain responsive and sustainable due to Fit manufacturing. It is the approach emphasizing on skilled and motivated workforce, flexible structure of organization and usage of IT technologies which are advanced [5].
Hence, fit manufacturing provides organizations a model to support their work in the direction of the 'staying healthy' [fit] goal in a specific time frame. This offers manufacturing organizations a framework through which resources can be allocated by them. Moreover, a balance can be formed by them among the different manufacturing initiatives. This also can cultivate appropriate metrics to evaluate and strengthen the firm's overall fitness. Additionally, disruptive forces of the organization can be responded through it. Figure 2 shows a current view of manufacturing strategiess with fit manufacturing being the modern initiative.
A fit enterprise, is usually lean, agile, and sustainable, and can keep up by creating value that meets or exceed customer expectations. An enterprise that is fit is also capable of responding to improvement changes – either by fixing the problem or by raising the fitness level - to adapt to the environmental.

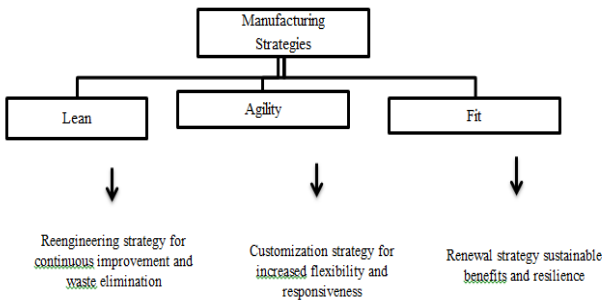

Fig. 2: A Contemporary View of Manufacturing Strategies

Before an organization can be designated as fit, the production firm should be able to establish five essential elements of a fit organization as illustrated in the preceding part in addition to details in figure 2 below. The figure shows that Fit Production System [FPS] is carried out by the parallel improvement of a firm's long-term strategic subsistence [sustainability] and functional competitiveness [leanness moreover, agility]. Combination of the various elements of production systems is indispensably essential, because these are able to perform collected function to achieve better efficiency with competitiveness[5]

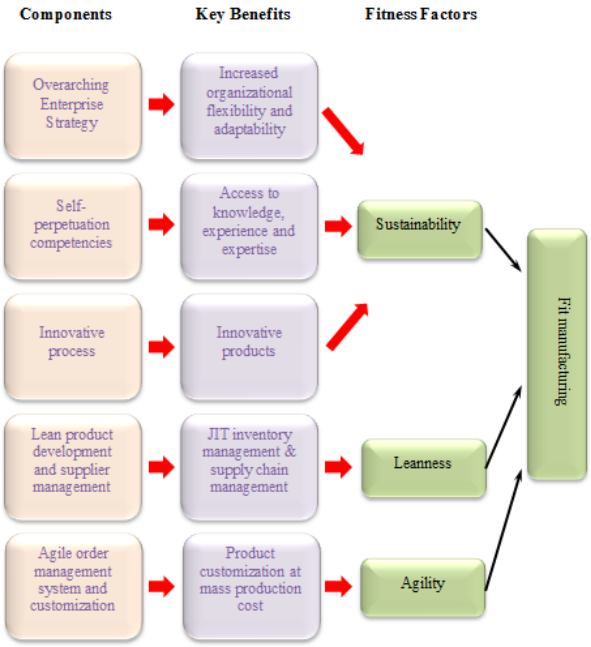

Fig. 3: Components of Fit Manufacturing System ,[5] ,p.94

3. Framework Construction

The Fit manufacturing system has become very importance in recent times. It is the successful integration of these two systems [i.e. Agile and Lean] with sustainability. Fit Manufacturing thus means the synchronization of Agile Manufacturing, sustainability and Lean Manufacturing. The consistent presence of a manufacturing system is guaranteed through the integration to manage the demands [14]. Additionally, global competition has compelled the origination of efficient and effective standards in response to the world economies for the objective of total performance improvement. Wider acceptability has been gained by agile and lean manufacturing recently. Elimination of the non-value added activities results in lean firm while agility mainly centers on market responsiveness [34]. Therefore, manufacturing sector is planning to enhance their business performance by application of these strategies. Although a considerable amount of the research established relationship of Fit manufacturing starategies and business performance. However, these studies have couple of limitations. First of all all these researchers are being conducted to the one set of Fit manufacturing strategy with business perforamnce. For example, [30] tested the relationship of sustainable manufacturing with business performance. While their study has neglected the other fit manufacturing strategies like lean and agile manufacturing strategies. Secondly, evidences lackning the consistant positive relationship of the Fit manufacturing strategies with business performance. This inconsistancy of the results leads to the investigation of the interviening effects between the relationship of Fit manufacturing strategies and business performance.
Most studies have indicated that globalization, changeable markets, improved product customization and competitive advantage present many challenges to manufacturing firms, both currently and in the future. In recent years, the expectations of consumers have

changed to provision of excellent quality, reliable delivery system and competitive pricing. A manufacturer's machines and processes are expected to have high level of reliability. In order to have machines with high reliability to ensure smooth manufacturing processes, several organizations have employed Total Productive Maintenance [TPM] as an enabling tool to enhance effectiveness of equipment and processes [35]. In recent times, techniques are being developed by the managers to manage and strategize the manufacturing processes and machines effectively. Challenges, of time wastage, overworked staff and energy are the factors faced by the most of manufacturing organizations [36]. Recently, a quantitative metrics for the measurement of the productivity of individual production equipment in factories commonly known as Overall Equipment Effectiveness [OEE] which was proposed by Nakajima in the late 1980s is increasingly gaining more popularity. Unlike the traditional metrics, such as the throughput and utilization rates, the OEE metrics offer a more comprehensive idea on the real dynamics of the system and hence offers better scope for identifying areas for productivity enhancement in the manufacturing system [19].

The OEE has been presented as a fresh technique that measures the machine effectiveness. Moreover, complex production problems can be made easier by Overall Equipment Effectiveness into simple presentation of information. It aids in the systematic analysis of the production processes, as it identifies potential areas of problems continually which may upset the machine usage [36]. Furthermore, it produces a quantitative metric based on performance, availability and quality which evaluates effectiveness of all processes and of a specific equipment [29]. Consequently, these organizations are trying to elevate the Business Process Management because of its attainment of the overall improvement in the quality of firms [37]. This proves that the overall equipment effectiveness can enhance the business performance. However, the fit manufacturing strategies enables organizations to use their equipment more effectively. Thus, the overall equipment effectiveness can mediate the relationship between fit manufacturing and business performance.

4. Conclusion and Recommendations

This paper examines the literature pertain the relationship between fit manufacturing strategies and business performance. The studies indicated that the different fit manufacturing strategies have positive link with business performance. However, literature is unable to establish consistency of this relationship. This indicates the presence of some mediating factors that influence the relationship between fit manufacturing and business performance. [4] argued that the overall equipment effectiveness can mediate the relationship between the fit manufacturing and business. However, this relationship has not been tested empirically. We recommend the future researchers to take this relationship into considerations for further explanations and implications in order to test this empirically.

References

[1] Qureshi MI, Rasli AM, Jusoh A, Kowang TO. Sustainability: A new manufacturing paradigm. Journal Teknologi. 2015;77[22]:47-53.

[2] Qureshi MI, Yusoff RM, Ahmed AR, Isa K, Imran A. Linking Quality of Work Life with Sustainable Manufacturing Performance. Advanced Science Letters. 2017;23[9]:8232-5.

[3] Yusoff RBM, Imran A, Qureshi MI, Kazi AG. Investigating the relationship of employee empowerment and sustainable manufacturing performance. International Review of Management and Marketing. 2016;6[4S].

[4] Pham DT, Thomas AJ. Fit manufacturing: a framework for sustainability. Journal of Manufacturing Technology Management. 2011;23[1]:103-23.

[5] Williams OA. Beyond lean: a framework for fit production systems: Cardiff University; 2013.

[6] Pham DT, Thomas AJ, Pham P. Fit manufacturing. Lean Enterprise Software and Systems: Springer; 2010. p. 162-74.

[7] Vinodh S, Sarangan S, Chandra Vinoth S. Application of fuzzy compromise solution method for fit concept selection. Applied Mathematical Modelling. 2014;38[3]:1052-63.

[8] Ebrahim Z. Fit manufacturing: Production fitness as the measure of production operations performance. United Kingdom: Cardiff University; 2011.

[9] Pham DT, Thomas A. Fighting fit factories: making industry lean, agile and sustainable. Manufacturing Engineer. 2005;84[2]:24-9.

[10] Pham D, Pham P, Thomas A. Fit Manufacturing. In: Abrahamsson P, Oza N, editors. Lean Enterprise Software and Systems. Lecture Notes in Business Information Processing. Berlin Springer Berlin Heidelberg; 2010. p. 162-74.

[11] Ebrahim Z, Wahab ANA, Shamsuddin T, editors. Fit Manufacturing: Analogy of Human Fitness Components. Applied Mechanics and Materials; 2015: Trans Tech Publ.

[12] Pham D, Pham P, Thomas A. Integrated production machines and systems–beyond lean manufacturing. Journal of Manufacturing Technology Management. 2008;19[6]:695-711.

[13] Sekar V, Vinoth C, Sundaram S. Assessment of fitness of a manufacturing organization using fuzzy methods. Journal of Manufacturing Technology Management. 2015;26[4]:561-81.

[14] Kutbi J. Fit enterprises: novel fitness indices for continuous improvement: Cardiff University; 2014.

[15] Thomas A, Pham D, editors. Making industry fit: the conceptualization of a generic'fit'manufacturing strategy for industry. Industrial Informatics, 2004 INDIN'04 2004 2nd IEEE International Conference on; 2004: IEEE.

[16] Ebrahim Z, Muhamad MR, Pham Duc T, editors. Fit manufacturing: Production Waste Index and its effect on Production Profitability. Industrial Engineering and Operations Management [IEOM], 2015 International Conference on; 2015 3-5 March 2015.

[17] Brousseau E, Eldukhri E. Recent advances on key technologies for innovative manufacturing. Journal of Intelligent Manufacturing. 2011;22[5]:675-91.

[18] Yusoff W, Yusmawiza WA, Mohd AA, Abdul Rahim SM. Design for manufacturer towards improved manufacturability In: Adesta YT, editor. The introduction of fit manufacturing as a performance measuring approach towards sustainability of selected manufacturing companies in Malaysia. Kuala Lumpur: IIUM Press 2011. p. pp. 105-12

[19] Nakajima S. Introduction to TPM: Total Productive Maintenance.: Cambridge; 1988.

[20] Nakajima S. TPM Development Program : Productivity Press: Cambridge; 1989.

[21] Huang SH, Dismukes JP, Shi J, Su Q, Razzak MA, Bodhale R, et al. Manufacturing productivity improvement using effectiveness metrics and simulation analysis. International Journal of Production Research. 2003;41[3]:513-27.

[22] Fleischer J, Weismann U, Niggeschmidt S. Calculation and optimisation model for costs and effects of availability relevant service elements. Proceedings of LCE. 2006:675-80.

[23] Nakajima S. Introduction to TPM: Total Productive Maintenance.[Translation]. Productivity Press, Inc, 1988. 1988:129.

[24] Muchiri P, Pintelon L. Performance measurement using overall equipment effectiveness [OEE]: literature review and practical application discussion. International Journal of Production Research. 2008;46[13]:3517-35.

[25] Bernstein R. Insights on Implementation TPM Collected practices and cases: New; 2005.

[26] Gram M. Equipment efficiency metrics in production systems. A literature review and survey. Book of proceedings of 9th International May Concefernce on Strategic Management–IMKSM. 2013:468-78.

[27] Pinto MM, Goldberg DJ, Cardoso JS. Benchmarking operational efficiency of port terminals using the OEE indicator. Maritime Economics & Logistics. 2016.

[28] Stamatis DH. The OEE primer: understanding overall equipment effectiveness, reliability, and maintainability: CRC Press; 2010.

[29] Garza-Reyes JA. From measuring overall equipment effectiveness [OEE] to overall resource effectiveness [ORE]. Journal of Quality in Maintenance Engineering. 2015;21[4]:506-27.

[30] Qureshi MI, Khan NU, Rasli AM, Zaman K. The battle of health with environmental evils of Asian countries: promises to keep. Environmental Science and Pollution Research. 2015;22[15]:11708-15.

[31] Chen L. Sustainability and company performance: Evidence from the manufacturing industry. Sweden: Linköping University; 2015.

[32] Othman R, Ameer R. Finance and Sustainability–Resources, Capabilities, and Rewards. Ethics, Governance and Corporate Crime: Challenges and Consequences [Developments in Corporate Governance and Responsibility, Volume 6] Emerald Group Publishing Limited. 2014;6:19-45.
[33] Barton R, Thomas AJ. Maximising the Effectiveness of Introducing Advanced Technologies. In: Pham DT, Eldukhri EE, Soroka AJ, editors. Intelligent Production Machines and Systems. Oxford: Elsevier Science Ltd; 2006. p. 632-7.
[34] Soltan H, Mostafa S. Lean and agile performance framework for manufacturing enterprises. Procedia Manufacturing. 2015;2:476-84.
[35] Bon AT, Lim M, editors. Total Productive Maintenance in automotive industry: Issues and effectiveness. Industrial Engineering and Operations Management [IEOM], 2015 International Conference on; 2015: IEEE.
[36] Singh R, Shah DB, Gohil AM, Shah MH. Overall Equipment Effectiveness [OEE] Calculation-Automation through Hardware & Software Development. Procedia Engineering. 2013;51:579-84.
[37] Menken I, Blokdijk G. The Business Process Management Guide:Practical Methodology and Guidelines to Successful BPM Implementation and Improvement Emereo; 2009.