

# Investigations In Productivity Improvement Using Effective Mapping Frame Work In Mechanical Industries With The Help Of Fuzzy Qfd: A Conceptual Review

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**Abstract:** In the present research work, contributions of researchers in the field of productivity improvement using value stream mapping (VSM) and fuzzy quality function deployment (FQFD) are acknowledged. The research paper portrays different aspects of research contributions and concludes with the investigated gaps of the research and objectives of the proposed research.

**Keywords:** Productivity, Value stream mapping (VSM), Fuzzy quality function deployment (FQFD), papers.

## 1. Introduction

Productivity stands as a pivotal and influential fundamental factor that governs economic production undertakings. Its connection to value generation is robust, with waste representing its contrasting concept. In light of this, every activity should contribute value to the customer; otherwise, it signifies a squandering of input resources. As an evaluative measure, productivity gauges an organization's adeptness in resource employment. Essentially, productivity is quantified by comparing output units to input units. Organizations striving to enhance productivity must aim to maximize this ratio to the greatest feasible extent. Productivity improvement is considered as one of the prominent requirements of industries, and one of the most discussed topics, since its inceptions, and even today, many researchers and industrialists work continuously in this field. Present research work presents the contributions of different researchers in the field of productivity improvement and concludes with the investigated gaps of the research and objectives of a new research.

## 2. Review of Literature

Present section deals with different aspects of the research work and presents contributions of researchers in the field of proposed work, and contributions of Indian researchers, as presented below.

### 2.1 Contributions of Researchers in the Field of Proposed Work

Following are the details of contributions of researchers in the field of productivity improvement, value stream mapping and fuzzy QFD.

- **Wang et al. (2020)**

The objective of this research is to explore the application of Value Stream Mapping (VSM), a lean methodology, in enhancing operational training performance. This enhancement is achieved through an immersive virtual reality (VR) personalized training program.

- **Murali et al. (2020)**

The study aims to enhance the productivity of a furniture manufacturing company. Central to this improvement is the significance of demand forecasts, which play a pivotal role in analyzing production planning challenges. By addressing issues related to demand forecasts, the study aims to mitigate problems such as overproduction and shortages.

- **Rose et al. (2020)**

The aim of this paper is to enhance the productivity of a specific company by systematically removing non-value-added activities. The case study takes place at the speaker unit of ABC Company in Malaysia. Initially, the existing value stream map of the production line is established using data from interviews, observations, and other company sources. Subsequently, a future value stream map is developed based on lean manufacturing principles. The initial value stream map revealed 12 non-value-added activities, while the revised map successfully eliminated 10 of them by implementing appropriate lean tools and techniques. This endeavor led to the identification and elimination of hidden waste sources, significantly boosting company performance with a remarkable 35% productivity increase and a 400% reduction in production lead time through the application of value stream mapping.

- **Rao et al. (2020)**

The aim of this study is to emphasize the significance of incorporating lean techniques within a medium-scale belt manufacturing industry. This research demonstrates the latent potential within the chosen sector, highlighting suitable techniques for augmenting productivity. The primary objective is to eliminate wasteful and non-value-added processes at each stage to enhance overall productivity. Following the implementation of pertinent lean techniques, the outcomes reveal a reduction of approximately 1256 minutes in lead time and a notable 9% increase in overall production.

- **Sutharsan et al. (2020)**

This paper delves into the utilization of lean manufacturing principles within the domain of pump manufacturing.

- **Ocampo et al. (2020)**

The case study findings reveal essential decision parameters for all stages, providing valuable input for design teams. In contrast to previous models, the suggested framework maintains the progression of priority flow throughout all four phases of product development, as emphasized by the researchers.

- **Opaleye et al. (2020)**

This study aims to analyze the factors that influence consumers' appreciation of typical Nigerian garment design (NGD). Employing survey data from 522 participants, a combined approach using quality function deployment (QFD) and the functional, expressive, and aesthetic (FEA) consumer needs method is used to accurately discern potential consumer requirements in mass-produced clothing. Among the sixteen identified quality attributes, six overarching themes emerged as key influencers of consumer satisfaction: (1) Style variety, (2) Dimensions, (3) Finishing, (4) Fabric quality, (5) Garment durability, and (6) Aesthetics. The study reveals that current NGD surpasses foreign designs in acceptance for informal events, style variety, and fit; however, improvements are required in other quality attributes.

- **De Oliveira et al. (2020)**

This paper seeks to examine existing literature concerning the concurrent application of Quality Function Deployment (QFD) and Analytic Hierarchy Process (AHP) methodologies. Additionally, it aims to conduct a thorough analysis of the publications stemming from this combined approach.

- **Opaleye & Kolawole (2020)**

This study aims to explore the factors influencing consumers' value perceptions regarding typical Nigerian garment design (NGD). Employing an integrated approach involving Quality Function Deployment (QFD) and the functional, expressive, and aesthetic (FEA) Consumer Needs methodology, the research strives to reduce misinterpretations of potential consumer preferences in mass-customized clothing. From the analysis, six key themes have emerged as drivers of consumer satisfaction: (1) Style variety, (2) Dimensions, (3) Finishing, (4) Fabric quality, (5) Garment durability, and (6) Aesthetics.

- **Lim et al. (2020)**

This study examines the service quality provided by a commercial cleaning company in Jakarta. It evaluates customer expectations across five SERVQUAL dimensions: tangibility, reliability, responsiveness, assurance, and empathy. Furthermore, internal quality is assessed using the Quality Function Deployment (QFD) method. Interviews and customer surveys were conducted, engaging 100 customers and 69 competitors' respondents. Findings highlight the significance of optimal performance, flexibility, and punctuality as critical customer requirements. Among technical improvements, recruitment, SOP, and soft skill training emerge as the top-priority areas for enhancing service quality.

- **Yu-Che et al. (2019)**

Incorporating the teaching curriculum, this research employs Quality Function Deployment (QFD) to facilitate a genuine comprehension and application of the Merchandise Presentation theory. By utilizing QFD, the study aligns with customer preferences and expert insights, effectively addressing the demands of Merchandise Presentation in mass merchandising, thus enhancing the practicality and realism of the theory.

- **Huang et al. (2019)**

This study utilizes Quality Function Deployment (QFD) to deconstruct and analyze the semantics of symbols representing the composition of fast fashion dress lines. This approach allows for the interpretation of dress symbol imagery, aiding online consumers in focusing on changes in the visual symbols of fast fashion dress silhouettes. It enables a deeper understanding of customer perceptions, bridging the gap between fast fashion design and customer preferences. By translating customer demand factors into analytical indicators, followed by rigorous screening and evaluation, this method facilitates the accurate selection of design decisions that align with both designers' and customers' needs. This approach serves as a valuable reference for the future design of virtual reality stores in the online network. The outcomes of this study also offer insights for the future design of online clothing imagery in VR, utilizing QFD's quality function to comprehend the clothing shopping preferences of diverse consumer generations. This facilitates the construction of a dynamic reference for image design and database establishment within the realm of online apparel design.

- **Hamja et al. (2019)**

This article adds to the ongoing discourse by examining the existing understanding of how lean practices influence both productivity and occupational health and safety (OHS) within the RMG industry.

- **Talapatra and Shefa (2019)**

The primary focus of this paper is the utilization of value stream mapping within a furniture industry's production floor, aimed at improving its overall performance.

- **Hatsey & Sileyew (2019)**

This paper explores the significance of Quality Function Deployment (QFD) and outlines strategies for effectively implementing QFD within the context of the industrial sector in Ethiopia.

- **Kays et al. (2019)**

The objective of the research study was to explore the potential for harmonizing cycle times to improve the operational efficiency of the RMG shop floor. This was achieved by employing an integrated lean approach, combining the use of Value Stream Mapping (VSM) and the Yamazumi chart.

- **Ahmed et al. (2019)**

This paper introduces a systematic framework for quantitatively assessing occupational risks within the context of the garments industry in Bangladesh. Additionally, it offers solutions to mitigate these identified risks.

- **Munoz-Villamizar et al. (2019)**

The objective of this paper is to present a novel approach referred to as "Overall Greenness Performance for Value Stream Mapping" (OGP-VSM).

- **Ozgormus et al. (2019)**

The aim of this paper is to put forth a structured strategy to address the personnel selection problem (PSP) within a Turkish textile company. This approach takes into account a range of performance criteria and requirements. The proposed framework is comprised of three distinct phases. First, the Fuzzy Decision-Making Trial and Evaluation Laboratory (DEMATEL) method is employed to assign weights to social criteria. Subsequently, the Fuzzy Quality Function Deployment (QFD) method is utilized to determine weights for technical requisites. This process facilitates the assessment of interdependencies and associations among both social and technical criteria.

- **Chowdhury et al. (2018)**

This research aims to pinpoint supply-side obstacles and their corresponding alleviation approaches within the context of the Bangladeshi apparel industry. This goal is pursued through the utilization of the analytical hierarchy process and the quality function deployment method.

- **Kapurja & Karmaker (2018)**

The paper demonstrates the process of discerning customer requirements and leveraging them to establish a hierarchy of design criteria for enhancing the quality of jute yarn. This involves the integration of Analytical Hierarchy Process (AHP) into the House of Quality (HOQ), providing a structured framework to overcome limitations associated with conventional Quality Function Deployment (QFD) techniques.

- **Kapurja Rahman (2018)**

This paper aims to introduce a model based on fuzzy quality function deployment (FQFD) to effectively recognize customer requirements, design the production process, and enhance the quality of T-shirts in alignment with those requirements.

- **Salahuddin (2018)**

The thesis aimed to examine consumers' and product developers' expectations regarding wearable technology products within the framework of Quality Function Deployment (QFD). The specific goals were to: 1) Investigate the key quality attributes that hold the most significance for consumers when purchasing wearable technology products. 2) Probe into the pivotal technical

characteristics that product developers prioritize in the creation of wearable technology. 3) Identify the specific technical aspects that wearable technology product developers should emphasize to align with customer requirements. This study aimed to uncover consumer priorities for wearable technology and ascertain the focal points of professionals involved in product development to ensure customer satisfaction. The findings offer valuable insights for both industry and academia.

- **Dorota Klimecka-Tatar (2017)**

The research work outlines the approach for enhancing the production process through the application of lean production tools.

- **Liao et al. (2017)**

The study focused on customers of the Credit Department within the Farmers' Association in Taiwan. Its aim was to investigate the disparity between the anticipated service quality and the actual perception of service quality among customers of the farmers' association.

- **Kumar et al. (2017)**

The study focused on an apparel industry and utilized Value Stream Mapping (VSM) to pinpoint bottleneck areas. By introducing line balancing and parallel working sections, these bottlenecks were eradicated. Through the application of kaizen principles, the cycle time was reduced by 48.7%. Furthermore, the value-added percentage increased from 0.397% to 0.431%, reflecting an 8.5% enhancement in process efficiency.

- **Ashrafuzzaman et al. (2016)**

This study employed Value Stream Mapping (VSM), a fundamental lean tool, to tackle the mentioned challenges within the context of Men's trouser production layout at ABC Ltd in India.

- **M. M. (2016)**

This case study delves into six chosen garments accessory industries (GAI) in Bangladesh, comparing them to 17 readymade garment industries and considering a buying house as a customer. The paper introduces an innovative approach to evaluating supply chain performance through a transformation matrix called quality function deployment. This novel system enables the measurement of supply chain performance across diverse manufacturing sectors. The research outcomes offer insights applicable to the selection of supply chain strategies for manufacturing industries.

- **Elleuch et al. (2016)**

This research has developed a methodology aimed at addressing vulnerabilities and enhancing supply chain resilience through a structured approach based on quality function deployment (QFD). The study focuses on mitigating vulnerabilities by bolstering supply chain resilience. Using the QFD method, the methodology identifies vulnerabilities and potential resilience capacities. It was applied to an agrifood company, specifically targeting their production supply

chain, with outcomes deemed relevant by the operational staff of ALCO Company. As a caveat, for handling uncertainties, employing fuzzy methods for binary comparison of vulnerabilities and assessing resilience against vulnerabilities can be considered. Extending this research, the selection of an efficient portfolio of resilience capacities could be achieved through multi-objective optimization methods like goal programming.

- **Jeong and Yoon (2016)**

This paper exemplifies the implementation of Value Stream Mapping (VSM) as a lean IT enhancement initiative within an IT company. The study involves the visualization of the firm's existing activities and the identification of potential enhancement prospects. Through employee interviews engaged in the process, the current state map delineates prevailing challenges. Furthermore, a future state map outlines the proposed action plans for improvement. The study underscores a reduction in lead time, cycle time, and resource allocation. The findings demonstrate a significant enhancement, indicating that the new process could curtail the total lead time from 20 days to merely 3 days, showcasing a remarkable 92% reduction in the overall lead time for the database provisioning process.

- **Oleghe and Saloniitis (2016)**

In this study, the researcher elucidated that the lean index is computed by aggregating the weighted scores of performance variables that encapsulate the lean manufacturing attributes within a system.

- **Mayatra et al. (2016)**

This paper focuses on examining the bearing industry in Ahmadabad, Gujarat, with the goal of diminishing product lead times and meeting customer demand.

- **Abreu & Calado (2015)**

The authors have crafted a comprehensive fuzzy logic model to assess the presence of lean thinking within an organization. This model's development stems from a qualitative assessment approach, supplemented by a quantitative foundation that draws upon fuzzy logic reasoning. The utilization of fuzzy logic is justified due to its capacity to handle uncertain and imprecise input data. Moreover, it facilitates the conversion of qualitative system variables into quantitative values. This approach was meticulously structured to create a model adaptable to the idiosyncrasies of any organizational type, independent of their characteristics such as nature, size, strategy, and market positioning.

- **Mohammad et al. (2015)**

The objectives of this project encompassed the identification of retention time, its underlying reasons, and the resultant outcomes through the utilization of Value Stream Mapping (VSM) methodology. Subsequently, the project aimed to propose suitable strategies for improvement. A real-world case study was carried out at Masco Knitwear Limited, Tongi, Bangladesh. The project meticulously delineates the value-added time, non-value-added time, and unavoidably non-value-added time across various sections within the studied company. The project's findings underscore

the noteworthy challenge posed by retention time (waiting time) in the company, which contributes to reduced productivity and an extended production lead time.

- **Chowdhury & Quaddus (2015)**

Given the increasing occurrence of disruptive events, organizations now face heightened susceptibility to their repercussions. Consequently, the imperative to cultivate a more robust supply chain (SC) to counteract these vulnerabilities has intensified. While supply chain resilience (SCR) and resilience indices have been explored in literature, the process of formulating and electing a range of supply chain resilience capabilities to counter vulnerabilities remains unexamined. In this study, researchers craft a 0-1 multi-objective optimization model using the QFD methodology.

- **Kumari et al. (2015)**

This study delves into the application of lean tools such as cellular manufacturing, Value Stream Mapping, single-piece flow, work standardization, and 5S within the garment industry. Lean manufacturing serves as a comprehensive approach to recognizing and eliminating production-related waste.

- **Akter et al. (2015)**

The ultimate aim of this paper is to enhance efficiency and productivity within the sewing floor of a luggage manufacturing plant. This is pursued through system simplification, process standardization, waste reduction, and incremental enhancements, facilitated by contemporary methods like Kaizen.

- **Migliano & Pantano (2015)**

This paper introduces a novel framework rooted in the quality function deployment (QFD) methodology, aiming to determine optimal technologies aligned with retailers' aspirations, consumers' requirements, and technical attributes. The framework's implementation holds advantages for the entire retail process.

- **Almomani et al. (2014)**

The scholars introduced a comprehensive amalgamation of a lean assessment model and the analytical hierarchy process, which furnishes a dynamic roadmap for implementing lean methodologies. They deduced that the execution of lean practices can differ based on the enterprise's specific circumstances.

- **Yildiz& Guner (2013)**

This study aimed to elucidate the value flow, waste generation, and sources of waste within the value stream through the application of value stream mapping. An analysis of the present state was conducted, and recommendations for enhancing system performance were put forward. It is



recommended that value stream mapping be conducted periodically to attain improved system performance through ongoing enhancement efforts.

- **Sujatha & Rao (2013)**

The primary objective was to create a value stream map depicting the existing state. Additionally, the study recognized certain processes suitable for subcontracting and proposed strategies for higher-level management to curtail non-value-added activities. The article delves into the potential reductions in setup and cycle times achievable through implementation. Moreover, it outlines a strategic course of action to enhance the Future State Value Stream Mapping (FVSM).

- **Jeyaraj et al. (2013)**

This paper contrasts the present and prospective states of a manufacturing company, revealing notable improvements. These include a 20% reduction in takt time, a 22.5% decrease in processing time, a 4.8% curtailment in lead time, a 20% enhancement in production, a 9% advancement in machine utilization, a 7% boost in manpower utilization, an evident elevation in worker skill levels, and a status quo in product and semi-finished product inventory levels.

- **Kumar & Sampath (2012)**

This paper revolves around a dual objective: first, to explore the implementation of Value Stream Mapping in the current production line, and second, to transform it with a novel cellular-based layout.

- **Jeyaraj et al. (2012)**

This paper examines the application of value stream mapping (VSM) as a tool for implementing lean manufacturing practices, along with a framework for enhancement initiatives. Specifically, it focuses on the effective integration of 5S and TPM through this approach.

- **Bennur & Jin (2012)**

This study presents a conceptual framework that integrates Kano's model and the quality function deployment (QFD) approach to implement quality attributes in apparel retail stores, thereby ensuring customer satisfaction. The research demonstrates a step-by-step application of the QFD process in efficiently implementing apparel store attributes, aiming to optimize efforts and enhance customer contentment. In this regard, QFD offers numerous advantages to retailers by enabling them to:

- Prioritize attributes sought by customers in an apparel store, based on Kano's attribute classification.
- Determine prioritized actions the company can undertake to meet customer needs.
- Evaluate the store's performance relative to its competitors.
- Set realistic target values that, if achieved, are likely to lead to customer satisfaction.

- Ensure the provision of improved products, processes, or services.

- **Chowdhury et al. (2012)**

This study seeks to pinpoint the significant obstacles hindering corporate sustainability and elucidate the process of alleviating these hindrances using an integrated AHP-QFD framework, illustrated through an in-depth case study. The findings of the study reveal that the mitigation efforts are categorized within the domains of strategic, tactical, and operational management.

- **Chowdhury et al. (2012)**

This study aims at identifying sustainability requirements of buyers in apparel industry and corresponding design requirements by applying fuzzy-QFD approach.

- **Chowdhury et al. (2012)**

The primary objective of this study is to pinpoint the barriers existing in the upstream supply chain of the RMG industry in Bangladesh. Additionally, the study endeavors to outline the corresponding design requirements for mitigation using an integrated approach that combines Analytical Hierarchy Process (AHP) with Quality Function Deployment (QFD).

- **S. K. P. N. (2012)**

This study strives to assess the suitability of "Value Stream Mapping (VSM)," a significant tool in Lean Manufacturing, within the Sri Lankan apparel industry. The results indicated the viability of applying VSM to mass production apparel sectors, yielding beneficial outcomes like waste reduction in inventory and defects. Furthermore, VSM facilitated the visualization of various waste types within the organization for the managers of the case company, along with potential avenues to eliminate or decrease them in the future.

- **Barai (2012)**

The article delves into an exploration of tools and techniques for enhancing productivity and examines the industry's current state. Employing the current state value stream mapping, it pinpoints recurring instances of waste. This mapping illustrates both the future state map and the potential for improvement. The future state map demonstrates potential waste reduction achievable through process enhancements, optimized machine utilization, and line balancing techniques.

- **Islam & Sultana (2011)**

This study focuses on the utilization of value stream mapping within the garments industry for the purpose of implementing lean manufacturing practices. Value stream mapping stands apart from conventional recording methods due to its capability to visually represent Material Flow, Information Flow, cycle times, and resource utilization.

- **Hasin (2011)**

This paper introduces a fuzzy Quality Function Deployment (QFD) framework tailored for enhancing the customer-perceived quality of synthetic fibers. It amalgamates the principles of traditional QFD methodology with fuzzy set theory to achieve this objective.

- **Chan et al. (2007)**

The main aim of this paper is to showcase a case study where Quality Function Deployment (QFD) is employed to structure and strategize the curriculum of a training course for novice clothing merchandisers in a buying office. The course is intended to equip them with the skills for conducting dimensional checks on samples. In contrast to conventional methods like 4-2-1 symbol weighting, this paper employs Analytical Hierarchy Process (AHP) to enhance the decision-making process in assessing the effectiveness of "HOWs" to achieve the specified goals in the quality matrix.

- **Diane (1999)**

This paper demonstrates the practicality and value of this product development tool within the apparel industry. This is achieved by creating a case study in the apparel sector and guiding it through the four matrices integral to the QFD process.

## 2.2 Contributions of Indian Researchers in the field of Productivity Improvement using Valued Stream Mapping & Fuzzy QFD

Table 2.1 shows the contributions of Indian researchers in the field of productivity improvement using value stream mapping and QFD.

**Table 2.1: Contributions of Indian Researchers in the field of Productivity Improvement using Valued Stream Mapping & QFD**

S. No	Researcher(s) (year)	Contribution
1	Sutharsan et al. (2020)	Enhancement in productivity and waste management in Indian manufacturing industry
2	Rao et al. (2020)	Productivity improvement Indian medium scale manufacturing industry using lean tools and VSM
3	Chaudhary et al. (2020)	Enhancement in productivity in electrical appliance industry
4	Nandakumar et al. (2020)	Investigations on bottlenecks and process improvements by lean six sigma DMAIC technique
5	Sivaraman et al. (2020)	Enhancement of productivity in engine assembly using lean manufacturing tools and techniques

6	Taifa and Vhora (2019)	Reduction in cycle time for improving productivity in manufacturing industry
7	Dhingra et al. (2019)	Cost reduction and quality improvement using Lean Kaizen concept
8	Jasti et al. (2019)	Application of VSM in auto ancillary industry
9	Singh et al. (2019)	Management of industrial operations using VSM and six sigma techniques
10	Jamwal et al. (2019)	Study of lean manufacturing barriers for small scale industries in Himachal region
11	Shah and Patel (2018)	Improvements in the productivity in manufacturing industry
12	Singh et al. (2018)	Productivity improvement using lean manufacturing in Northan India based industry
13	Kumar et al. (2018)	Implementation of Lean-KAIZEN principles in SMEs
14	Kumar et al. (2018)	Application of KAIZEN using VSM-Fuzzy-TOPSIS for small scale enterprises
15	Kumar et al. (2018)	Process enhancements using Lean-Kaizen and VSM approaches
16	Verma and Sharma (2017)	Implementation of lean practices on SME
17	Nallusamy and Saravanan (2016)	Lean tools execution in small scale manufacturing industry using VSM
18	Azizi (2016)	Design of VSM for reducing lead time
19	Gunaki et al. (2015)	Review of productivity improvements using VSM
20	Helleno et al. (2015)	Integration of VSM and discrete event simulation for operations management
21	Saboo et al. (2014)	VSM improvement based approach for Indian SME
22	Das et al. (2014)	Application of lean manufacturing system in air-conditioning coil manufacturing industry
23	Jeyaraj et al. (2013)	Applications of VSM in manufacturing company
24	Mathur et al. (2012)	Enhancements in productivity in Indian SMEs
25	Bhat and Shaivakumar (2011)	Enhancement in productivity using VSM and KANBAN
26	Vinodh et al. (2010)	Application of VSM in camshaft manufacturing industry
27	Singh et al. (2010)	Investigations on lean manufacturing and its benefits
28	Singh and Sharma (2009)	Applications of VSM in Indian manufacturing firm
29	Seth et al. (2008)	Applications of VSM in Cottonseed Oil industry

### 3. Gaps in the Research and Objectives of Proposed Research

Present section deals with the gaps of the research and objectives of proposed research, as follows.

### 3.1 Gaps in the Research

On the basis of the survey of available literature it was found that there is very less research papers available which focus on the investigations on productivity enhancement using quality function deployment value stream mapping technique, which lead the foundation of the research work.

**On the basis of gaps in the research title & objectives of the research work have been finalized.**

### 3.2 Objectives of the research

Following are the objectives of the present research work:

**a) Development of integrated VSM-Fuzzy QFD framework for an existing firm**

With the help of integrated VSM-QFD framework, the existing performance of the firm shall be investigated on different parameters.

**b) Investigations on the rankings of different parameters for the firm**

With the help of this objective, ranking of different parameters, like logistic system improvement, 5S, Kanban, Kaizan, etc shall be investigated.

**c) Investigations on important parameters for the firm**

With the help of this objective, investigations on the importance parameters for the firm shall be made.

### 4. Concluding Remarks

Present research paper focuses on different academic aspects of the research, acknowledges the contributions of researchers in different manners, and concludes with the investigated gaps in the existing research and objectives of proposed research. Considering the today's dire needs of industries for enhanced production, the research work seems to be appropriate.

### References and Web Resources

- Abreu, António, and João Manuel Ferreira Calado. "A fuzzy logic model to evaluate the lean level of an organization." *International Journal of Artificial Intelligence and Applications (IJAIA)* 8, no. 5 (2015), pp. 59-75.
- Ahmed, S. M., Chitra Lekha Karmaker, and Md Ahmed. "Assessment of safety, health and environmental risk factors in garments industries of Bangladesh." *Journal of applied research on industrial engineering* 6, no. 3 (2019), pp. 161-176.
- Akter, Saima, Farasat Raiyan Yasmin, and Md Ariful Ferdous. "Implementation of kaizen for continuous improvement of productivity in garment industry in Bangladesh." *American Academic & Scholarly Research Journal* 7, no. 3 (2015).
- Almomani, Mohamed Ali, Abdelhakim Abdelhadi, Ahmad Mumani, Amer Momani, and Mohammed Aladeemy. "A proposed integrated model of lean assessment and analytical

- hierarchy process for a dynamic road map of lean implementation." *The International Journal of Advanced Manufacturing Technology* 72, no. 1 (2014), pp. 161-172.
- Ashrafuzzaman, Md, Abdullah Al-Maruf, I. M. Mahbubul, ABM Abdul Malek, and A. M. M. Mukaddes. "Quality function deployment approach to measure supply chain performance: a case study on garments accessories industries." *International Journal of Industrial and Systems Engineering* 22, no. 1 (2016), pp. 96-120.
  - Azizi, Amir. "Designing a future value stream mapping to reduce lead time using SMED-A case study." *Procedia Manufacturing* 2 (2015) , pp. 153-158.
  - Barai, Piyush Kanti. "Improvement of production line efficiency using process improvement techniques through Value Stream Mapping (VSM)-a case study." (2012).
  - Bennur, Shubhapriya, and Byoungcho Jin. "A conceptual process of implementing quality apparel retail store attributes: An application of Kano's model and the quality function deployment approach." *International Journal of Business, Humanities and Technology* 2, no. 1 (2012) , pp. 174-183.
  - Bhamu, Jaiprakash, J. V. Shailendra Kumar, and Kuldip Singh Sangwan. "Productivity and quality improvement through value stream mapping: a case study of Indian automotive industry." *International Journal of Productivity and Quality Management* 10, no. 3 (2012) , pp. 288-306.
  - Bhat, R., and S. Shivakumar. "Improving the productivity using value stream mapping and kanban approach." *International Journal of Scientific & Engineering Research* 2, no. 8 (2011) , pp. 2229-5518.
  - Chan, C. Y., Chan, K., & Ip, W. C. *Applying QFD to Design Vocational Training Course for Clothing Merchandisers.* (2007)
  - Chaudhary, Anil, Ashish Kumar Singh, and M. L. Meena. "Productivity improvement of an electrical appliance industry by implementing lean manufacturing tools and a low-cost intervention (a case study)." *International Journal of Productivity and Quality Management* 31, no. 3 (2020) , pp. 390-411.
  - Chowdhury, Md Maruf Hossan, and Mohammed A. Quaddus. "A multiple objective optimization based QFD approach for efficient resilient strategies to mitigate supply chain vulnerabilities: The case of garment industry of Bangladesh." *Omega* 57 (2015), pp. 5-21.
  - Chowdhury, Md, Maruf Hossan, Nusrat Jusy Umme, and Md Nuruzzaman. "Strategies for mitigating supply-side barriers in the apparel supply chain: A study on the apparel industry of Bangladesh." *Global Journal of Flexible Systems Management* 19, no. 1 (2018), pp. 41-52.
  - Chowdury, M. H., M. Dewan, Md Moazzem Hossain, and M. Quaddus. "An AHP-QFD integrated approach for mitigating the barriers of corporate sustainability." (2012).
  - Das, Biman, Uday Venkatadri, and Pankajkumar Pandey. "Applying lean manufacturing system to improving productivity of airconditioning coil manufacturing." *The International Journal of Advanced Manufacturing Technology* 71, no. 1 (2014), pp. 307-323.

- de Oliveira, Leonardo Medeiros Vaz, Hugo Ferreira dos Santos, Mariana Rodrigues de Almeida, and Jose Alfredo Ferreira Costa. "Quality Function Deployment and Analytic Hierarchy Process: A literature review of their joint application." *Concurrent Engineering* 28, no. 3 (2020), pp. 239-251.
- Dhingra, A. K., Kumar, S., & Singh, B. (2019). Cost reduction and quality improvement through Lean-Kaizen concept using value stream map in Indian manufacturing firms. *International Journal of System Assurance Engineering and Management*, 10(4) , pp. 792-800.
- Elleuch, H., E. Dafaoui, A. El Mhamedi, and H. Chabchoub. "A quality function deployment approach for production resilience improvement in supply chain: case of agrifood industry." *IFAC-PapersOnLine* 49, no. 31 (2016), pp. 125-130.
- Gunaki, Pradip, S. N. Teli, and Fauzia Siddiqui. "A Review Paper on Productivity Improvement by Value Stream Mapping." *Journal of Emerging Technologies and Innovative Research* 2, no. 4 (2015) , pp. 1119-1124.
- Hamja, Abu, Malek Maalouf, and Peter Hasle. "The effect of lean on occupational health and safety and productivity in the garment industry—a literature review." *Production & Manufacturing Research* 7, no. 1 (2019), pp. 316-334.
- Hasin, M. Ahsan Akhtar. "Customer perceived quality improvement of synthetic fiber using fuzzy QFD: a case study." *Center for Quality* (2011).
- Hatsey, Niguss Haregot, and Kassu Jilcha Sileyew. "Quality function deployment knowledge transfer to Ethiopian industries and how it can be implemented." *Branna Journal of Engineering and Technology* 1, no. 1 (2019), pp. 1-19.
- Helleno, A. L., C. A. Pimentel, R. Ferro, P. F. Santos, M. C. Oliveira, and A. T. Simon. "Integrating value stream mapping and discrete events simulation as decision making tools in operation management." *The International Journal of Advanced Manufacturing Technology* 80, no. 5 (2015) , pp. 1059-1066.
- Huang, Yu-Che, and Chia-Cheng Hsu. "Network virtual reality clothing silhouette design influencing factors." In *2019 IEEE 4th International Conference on Signal and Image Processing (ICSIP)*, pp. 707-711. IEEE, 2019.
- Islam, MM Nazrul, and Mimmun Sultana. "Strating the Lean Journey With Value Stream Mapping in the Garments Industry of Bangladesh." In *Proceedings of the International Conference on Mechanical Eng*, pp. 18-20. 2011.
- Jamwal, Anbesh, Ankur Aggarwal, Sumit Gupta, and Parul Sharma. "A study on the barriers to lean manufacturing implementation for small-scale industries in Himachal region (India)." *International Journal of Intelligent Enterprise* 6, no. 2-4 (2019), pp. 393-407.
- Jasti, Naga Vamsi Krishna, Srinivas Kota, and Kuldip Singh Sangwan. "An application of value stream mapping in auto-ancillary industry: A case study." *The TQM Journal* 32, no. 1 (2019) , pp. 162-182.

- Jeong, Bong Keun, and Tom E. Yoon. "Improving IT process management through value stream mapping approach: A case study." *JISTEM-Journal of Information Systems and Technology Management* 13 (2016), pp. 389-404.
- Jeyaraj, K. L., C. Muralidharan, R. Mahalingam, and S. G. Deshmukh. "Applying value stream mapping technique for production improvement in a manufacturing company: a case study." *Journal of The Institution of Engineers (India): Series C* 94, no. 1 (2013) , pp. 43-52.
- Jeyaraj, K. L., C. Muralidharan, R. Mahalingam, and S. G. Deshmukh. "Applying value stream mapping technique for production improvement in a manufacturing company: a case study." *Journal of The Institution of Engineers (India): Series C* 93, no. 1 (2012) , pp. 1-15.
- Jeyaraj, K. L., C. Muralidharan, R. Mahalingam, and S. G. Deshmukh. "Applying value stream mapping technique for production improvement in a manufacturing company: a case study." *Journal of The Institution of Engineers (India): Series C* 94, no. 1 (2013), pp. 43-52.
- Kapuria, Taposh Kumar, and C. L. Karmaker. "Customer Driven Quality Improvement of Jute Yarn Using AHP Based QFD: A Case Study." *International Journal for Quality Research* 12, no. 1 (2018).
- Kapuria, Taposh Kumar, and Mustafizur Rahman. "Quality improvement of T-shirt using fuzzy QFD: a case study." *International Journal of Management Concepts and Philosophy* 11, no. 4 (2018), pp. 393-414.
- Kays, HM Emrul, S. Prodhana, Noorliza Karia, A. N. M. Karim, and Sazzad Bin Sharif. "Improvement of operational performance through value stream mapping and Yamazumi chart: A case of Bangladeshi RMG industry." *Int J Recent Technol Eng* 8, no. 4 (2019), pp. 11977-11986.
- Klimecka-Tatar, Dorota. "Value stream mapping as lean production tool to improve the production process organization—case study in packaging manufacturing." *Production Engineering Archives* 17, no. 17 (2017), pp. 40-44.
- Kumar, B. Senthil, and V. R. Sampath. "Garment manufacturing through lean initiative-an empirical study on WIP fluctuation in T-shirt production unit." *International Journal of Lean Thinking* 3, no. 2 (2012) , pp. 102-116.
- Kumar, Sunil, Ashwani Dhingra, and Bhim Singh. "Lean-Kaizen implementation: A roadmap for identifying continuous improvement opportunities in Indian small and medium sized enterprise." *Journal of Engineering, Design and Technology* (2018).
- Kumar, Sunil, Ashwani Kumar Dhingra, and Bhim Singh. "Kaizen selection for continuous improvement through VSM-Fuzzy-TOPSIS in Small-Scale enterprises: An Indian case study." *Advances in Fuzzy Systems* 2018 (2018).
- Kumar, Sunil, Ashwani Kumar Dhingra, and Bhim Singh. "Process improvement through Lean-Kaizen using value stream map: a case study in India." *The International Journal of Advanced Manufacturing Technology* 96, no. 5 (2018) , pp. 2687-2698.



- Kumari, Rashmi, T. Z. Quazi, and Rishi Kumar. "Application of lean manufacturing tools in garment industry." *International Journal Of Mechanical Engineering And Information Technology* 3, no. 1 (2015) , pp. 976-982.
- Liao, Wei-Nien, Tseng-Chung Tang, and Li-Chiu Chi. "A Study of Applying Quality Function Deployment & Service Quality Model to Service Quality of Credit Department of Farmers' Association—a Case Study in Taiwan." *International Research Journal of Applied Finance* 8, no. 2 (2017), pp. 47-69.
- Lim Sanny, Milka, Yessica Claralisa, Ika Triana, and Ulf Henning Richter. "Quality Function Deployment and Servqual based Service Quality Analysis: Commercial Cleaning Company Case in Jakarta, indonesia." *PalArch's Journal of Archaeology of Egypt/Egyptology* 17, no. 7 (2020), pp. 3067-3080.
- Mathur, Alok, M. L. Mittal, and Govind Sharan Dangayach. "Improving productivity in Indian SMEs." *Production Planning & Control* 23, no. 10-11 (2012) , pp. 754-768.
- Mayatra, Mehul, N. D. Chauhan, Parthiv Trivedi, and M. N. Qureshi. "Implementation of value stream mapping Methodology in Bearing Industry." *International Journal of advance Research, Ideas and Innovations in Technology*, 2 (3) (2016).
- Migliano, Giuseppe, and Eleonora Pantano. "Improving the quality of technology-based innovations selection: a quality function deployment approach for retailers." *International Journal of Business Performance Management* 16, no. 2-3 (2015) , pp. 352-372.
- Mohammad, Azim, Shibir Ahmad, and Mohammad Iqbal. "Identification of retention time & information delays applying value stream mapping technique in apparel manufacturing organization." In *Proceedings of the 2015 International Conference on Operations Excellence and Service Engineering Orlando, Florida, USA, September*, pp. 10-11. 2015.
- Muñoz-Villamizar, Andrés, Javier Santos, Julio J. Garcia-Sabater, Alvaro Lleo, and Paloma Grau. "Green value stream mapping approach to improving productivity and environmental performance." *International Journal of Productivity and Performance Management* (2019).
- Murali, C. Shyam, and A. Prabukarthi. "Productivity improvement in furniture industry using lean tools and process simulation." *International Journal of Productivity and Quality Management* 30, no. 2 (2020), pp. 214-233.
- Nallusamy, S., and V. Saravanan. "Lean tools execution in a small scale manufacturing industry for productivity improvement-A case study." *Indian Journal of Science and Technology* 9, no. 35 (2016) , pp. 01-07.
- Nandakumar, Nikhil, P. G. Saleeshya, and Priya Harikumar. "Bottleneck identification and process improvement by lean six sigma DMAIC methodology." *Materials Today: Proceedings* 24 (2020) , pp. 1217-1224.
- Ocampo, Lanndon A., John James T. Labrador, Ammabelle Marie B. Jumao-as, and Alona Mae O. Rama. "Integrated multiphase sustainable product design with a hybrid quality

- function deployment–multi-attribute decision-making (QFD-MADM) framework." *Sustainable Production and Consumption* 24 (2020), pp. 62-78.
- Oleghe, Omogbai, and Konstantinos Salonitis. "Variation modeling of lean manufacturing performance using fuzzy logic based quantitative lean index." *Procedia Cirp* 41 (2016), pp. 608-613.
  - Opaleye, A. A., Kolawole, A., & Opaleye, M. A. (2020) An Integrated QFD-FEA Framework for Evaluation of Nigeria Garment Designs, *European Scientific Journal* May 2020 edition Vol.16, No.13 ISSN: 1857-7881 (Print) e - ISSN 1857-7431.
  - Ozgormus, E. G. G. H. S. A., A. Senocak, and H. G. Goren. "An integrated fuzzy QFD-MCDM framework for personnel selection problem." *Scientia Iranica* 28, no. 5 (2019) , pp. 2972-2986.
  - Paunovic, Danijela, Gordana Colovic, and Vladimir Nikolic. "The quality function deployment method in garment industry." *Communications in Dependability and Quality Management* 12, no. 2 (2009) , pp. 51-60.
  - Punna Rao, Gunji Venkata, S. Nallusamy, P. S. Chakraborty, and S. Muralikrishna. "Study on productivity improvement in medium scale manufacturing industry by execution of lean tools." In *International Journal of Engineering Research in Africa*, vol. 48, pp. 193-207. Trans Tech Publications Ltd, 2020.
  - Punna Rao, Gunji Venkata, S. Nallusamy, P. S. Chakraborty, and S. Muralikrishna. "Study on productivity improvement in medium scale manufacturing industry by execution of lean tools." In *International Journal of Engineering Research in Africa*, vol. 48, pp. 193-207. Trans Tech Publications Ltd, 2020.
  - Rose, A. N. M., N. M. Z. N. Mohamed, H. M. Noor, and A. Mohd. "Improving productivity through value stream mapping (VSM): A case study at electrical & electronic company." In *Journal of Physics: Conference Series*, vol. 1532, no. 1, pp. 012005. IOP Publishing, 2020.
  - Saboo, Aayush, Jose Arturo Garza-Reyes, Ahmet Er, and Vikas Kumar. "A VSM improvement-based approach for lean operations in an Indian manufacturing SME." *International Journal of Lean Enterprise Research* 1, no. 1 (2014) , pp. 41-58.
  - Salahuddin, Mir. *Quality Function Deployment Method and Its Application on Wearable Technology Product Development*. Louisiana State University and Agricultural & Mechanical College, 2018.
  - Scheurell, Diane M. "Applying quality function deployment in the apparel industry." *The International Journal of Costume Culture* 2, no. 2 (1999) , pp. 14-30.
  - Seth\*, Dinesh, and Vaibhav Gupta. "Application of value stream mapping for lean operations and cycle time reduction: an Indian case study." *Production Planning & Control* 16, no. 1 (2005) , pp. 44-59.
  - Seth, Dinesh, Nitin Seth, and Deepak Goel. "Application of value stream mapping (VSM) for minimization of wastes in the processing side of supply chain of cottonseed oil industry in Indian context." *Journal of manufacturing technology management* (2008).

- Shah, Dhruv, and Pritesh Patel. "Productivity improvement by implementing lean manufacturing tools in manufacturing industry." *International Research Journal of Engineering and Technology* 5, no. 3 (2018) , pp. 3-7.
- Silva, S. K. P. N. "Applicability of value stream mapping (VSM) in the apparel industry in Sri Lanka." *International journal of lean thinking* 3, no. 1 (2012) , pp. 36-41.
- Singh, Bhim, and S. K. Sharma. "Value stream mapping as a versatile tool for lean implementation: an Indian case study of a manufacturing firm." *Measuring business excellence* (2009).
- Singh, Bhim, S. K. Garg, and S. K. Sharma. "Scope for lean implementation: a survey of 127 Indian industries." *International Journal of Rapid Manufacturing* 1, no. 3 (2010) , pp. 323-333.
- Singh, Bhim, S. K. Garg, S. K. Sharma, and Chandandeep Grewal. "Lean implementation and its benefits to production industry." *International journal of lean six sigma* (2010).
- Singh, Jagdeep, Harwinder Singh, Amandeep Singh, and Jashanpreet Singh. "Managing industrial operations by lean thinking using value stream mapping and six sigma in manufacturing unit: Case studies." *Management decision* (2019).
- Singh, Jagdeep, Harwinder Singh, and Gurpreet Singh. "Productivity improvement using lean manufacturing in manufacturing industry of Northern India: A case study." *International Journal of Productivity and Performance Management* (2018).
- Sivaraman, P., T. Nithyanandhan, S. Lakshminarasimhan, S. Manikandan, and Mohamad Saifudheen. "Productivity enhancement in engine assembly using lean tools and techniques." *Materials Today: Proceedings* 33 (2020) , pp. 201-207.
- Song, Chao, Jian-Qiang Wang, and Jun-Bo Li. "New framework for quality function deployment using linguistic Z-numbers." *Mathematics* 8, no. 2 (2020), pp. 224.
- Suhardi, Bambang, Maudiena Hermas Putri KS, and Wakhid Ahmad Jauhari. "Implementation of value stream mapping to reduce waste in a textile products industry." *Cogent Engineering* 7, no. 1 (2020), pp. 1842148.
- Sujatha, Y., and K. Prahlada Rao. "Implementation of a lean model for carrying out value stream mapping in a silk reeling process industry." *Editorial Committees* (2013) , pp. 13.
- Sutharsan, S. M., M. Mohan Prasad, and S. Vijay. "Productivity enhancement and waste management through lean philosophy in Indian manufacturing industry." *Materials Today: Proceedings* 33 (2020), pp. 2981-2985.
- Sutharsan, S. M., M. Mohan Prasad, and S. Vijay. "Productivity enhancement and waste management through lean philosophy in Indian manufacturing industry." *Materials Today: Proceedings* 33 (2020) , pp. 2981-2985.
- Taifa, Ismail, and Tosifbhai Vhora. "Cycle time reduction for productivity improvement in the manufacturing industry." *Journal of Industrial Engineering and Management Studies* 6, no. 2 (2019) , pp. 147-164.
- Talapatra, Subrata, and Jannatul Shefa. "Application of Value Stream Mapping to Improve Financial Performance of a Production Floor: a Case Study." In *Proceedings of the*

International Conference on Industrial Engineering and Operations Management Bangkok, Thailand, March, pp. 5-7. 2019.

- Verma, Neha, and Vinay Sharma. "Sustainable competitive advantage by implementing lean manufacturing "A Case study for Indian SME"." *Materials Today: Proceedings* 4, no. 8 (2017) , pp. 9210-9217.
- Vikas Kumar, Jose Arturo Garza-Reyes, and Andreadis, Eleftherios. "Towards a conceptual framework for value stream mapping (VSM) implementation: an investigation of managerial factors." *International Journal of Production Research* 55, no. 23 (2017), pp. 7073-7095.
- Vinodh, S., K. R. Arvind, and M. Somanaathan. "Application of value stream mapping in an Indian camshaft manufacturing organisation." *Journal of Manufacturing Technology Management* (2010).
- Wang, Peng, Peng Wu, Hung-Lin Chi, and Xiao Li. "Adopting lean thinking in virtual reality-based personalized operation training using value stream mapping." *Automation in Construction* 119 (2020), pp. 103355.
- Yildiz, Esra Zeynep, and MÜCELLA GÜNER. "Applying value stream mapping technique in apparel industry." *Tekstil ve Konfeksiyon* 23, no. 4 (2013) , pp. 393-400.
- Yu-Che, Huang, Chen Chia-Chi, and Hsu Chia-Cheng. "Research on the Application of QFD in the Merchandise Presentation of Budget Accessories in the Hypermarket." In *Proceedings of the 2019 The 3rd International Conference on Digital Technology in Education*, pp. 21-24. 2019.