International Journal of Psychosocial Rehabilitation, Vol. 24, Issue 06,
2019 ISSN: 1475-7192

3D printing: A new pacesetter of industry 4.0 set to reduce the pollution of logistics cost

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. ***Abstract—*** *This paper explores the evolution of printing created by the revolution of industry 4.0 in which 3D printing technology emerges as one of the trendsetter's for the purpose of reducing logistics cost. Despite of the existence of technology during the third industrial revolution, 3D printing only emerged into extensive manufacturing digitalization in the fourth industrialization. Manufacturing and the logistics activities have constantly improvised through innovative measures to enhance processes to become more lean and agile. However, conventional manufacturing is less flexible, creates excessive wastages, can only achieve economies of scale when producing large quantity of products and longer time is taken to produce a new product. Breakthroughs in information technology, mobile communications and robotics have led to the growing use of digital technologies in factories around the world. This transformation has come to be known as Industry 4.0 or the Fourth industrial revolution. As such, 3D printing being part of the 4.0 revolution holds the ability to reduce costs that surfaces in logistics activities which could also improve manufacturing cost ultimately*

Keywords— *3D printing, industrial 4.0, logistics cost, collaborative innovation*

I INTRODUCTION

A revolutionary way of manufacturing via printing process which was just an idea toyed in the 1980's finally made its way into reality in 1986 when an engineer identified as Charles Hull formed an archetype for a process termed as stereo lithography or more commonly known as the 3D printing. An acrylic-based ingredients or better known as photopolymers that transforms itself from liquid to solid form using ultraviolet lights became more mainstream in year 2005 due to its innovative features.

3D printing has been making its inroads into the manufacturing arena by producing goods on request in small consignment sizes while making them available to the end consumer in a tailor made manner closer to them. This implementation had caused a significant impact in the reduction of the logistics cost pollution. Fundamentally, the whole 3D printing activity will be largely perceived to be a disruptive element to the ever essential existence of logistics industry to a certain extent. In a globalized world where the logistics activity is shrinking in its service offerings in light of the emergence of e-commerce, the 3D printing is further deepening the impact.

Progressively, supply chains are affected by the fourth industrial innovation through digitized practices and exponential development of sensible information. The expression of "Industry 4.0" is characterized by its seven attributes and interrelated features. Moreover, related advancements and ideas are approved to decide their commitment to the future improvement of the modern upheaval. According to Cachon, P. G., (2012), three intriguing theory are expressed, completing the effect of Industry 4.0 from an auxiliary, innovative and authoritative viewpoint. To start with,

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the improvement of steam machines definitely changed the generation forms.

Electrical drives, ignition motors and the inventive sequential construction system generation frameworks at that point started the second modern insurgency. The third industrial revolution was predominantly portrayed by the colossal robotization of the creation forms (Bauernhansl, T. et al, 2014) which is the reason for the progressing fourth modern insurgency, where we confront complex frameworks of equipment, server farms and programming parts in a single item (Brettel, M.,et al., 2014).

Customary boundaries for items and their incentives are greatly expanded and hence, existent value chains and the particular supply chain are to be re-evaluated (Porter, M.E., Heppelmann, J.E., 2015). The social, economic, and technical 3D printing revolution is on the way. The entrepreneurs, policy makers, and society at large will encounter unforeseen opportunities and challenges. As such, an area that will be massively disrupted is the supply chain industry. Transport Intelligence website released a report “The Implication of 3D Printing for the Global Logistics Industry,” mentioning that 3D printing technology will bring about the production activities in Asia to return to North America and Europe.

It will lead to the decline in the shipping and air cargo volume. The transportation cost saved is incredible. Jin et al, (2014) proposed that, in addition to the global freight volume reduction, the level of inventory will also decline. This is because 3D printing can improve the efficiency of the production as needed. Lower transportation and warehousing business will force logistics enterprises to transform. That includes merging 3D printing into logistics activities, focusing on 3D printing material logistics and developing the supply-chain control tower business.

II LITERATURE REVIEW

The purpose of this research is to exhibit a conceptual context that expose the cost factors incorporated into the stock conveying cost calculation in different relevant settings, and determine valuable recommendations and contemplations for handy application. As a rule, any theoretical framework requires to accumulate strong inventory cost parameters with a specific end goal to drive logisticians' basic leadership, both for coordination and administration purposes (Daugherty, P.J et. al., 2011; Defee, C.C et. al., 2010 & Randall, W.S et. al., 2011).

Almost all the literature on optimal inventory management uses criteria of cost minimization or profit maximization. An inventory managers’ goal for example, is modeled as minimizing cost or maximizing profit while satisfying customers’ demands. If inventory decisions do not affect the revenue stream, these two criteria result in the same optimal replenishment policy. Excess inventory consumes physical space, creates a financial burden, and increases the possibility of damage, spoilage and loss Dilupa Nakandala, Henry Lau, Jingjing Zhang, (2017). Further, excessive inventory frequently compensates for sloppy and inefficient management.

The inventory expenses can be decreased with the usage of information mining-based recharging approach. A choice tree-based model for stock recharging in retail locations has been proposed in Bala,P.K.(2009b). Decision tree is inducted using data mining on sale transaction data of purchased items with the demographic profile and other details of the customers. Nevertheless, these models never discuss the estimating and importance of accuracy in forecasting in the execution of stock in store network administration. Inventory professional confront a nonstop expanding strain to accomplish cost advancement, a circumstance that has been exacerbated by escalating rivalry and expanded customer’s demand for more intensely estimated results of better quality Dimitrios P. Koumanakos, (2008). Firms must be proactive in deliberately searching for new markets and in the meantime hold their current clients on the off chance that they are to survive. While upholding high stock levels that creates high consumer loyalty and consistency through quality supply, where firms need to recognize the base manageable stock level with a specific end goal to hinder the high stock cost. At the point when firms find that request can't be met with stock available, they should think about sourcing it from another substance in a similar echelon; such access empowers quick conveyance however comes at an impressively higher cost (Seidscher, A. and Minner, S. (2013).

III INDUSTRY 4.0 EXHIBITS THE LOGISTICS VISIBILITY

Industry 4.0 particularly includes a radical move in how logistics tasks currently work. Global change of the logistics business by the presentation of digitalization and the Internet, these changes consider the progressive enhancements in the outline and manufacturing procedures, activities and administrations of assembling items and frameworks Anna Azzi et. al., (2014). New imaginative improvements in computerized innovation including "propelled mechanical autonomy and manmade brainpower, hi-tech sensors, cloud computing, the Internet of Things, data capture and analytics, advanced creation (3D printing), software programming and devices (B.Tjahjono, et. al, 2017).

The implementation of specific advancements, for example, virtual and augmented realities, 3D-Printing and restoration will result the chances of expanded adaptability, quality principles, effectiveness and profitability. This will empower niche developments, enabling organizations to meet clients' requests, making an incentive through continually acquainting new items and administrations with the market. Besides, the coordinated effort amongst machines and people could socially affect the life of the laborers without bounds, particularly as for the enhancement of coordination basic leadership (H. W. Lin et. al,. 2012).

Moreover, in a hierarchical structure perspective, Industry 4.0 incorporates horizontal amalgamation through an interior collaboration, vertical combination of subsystems inside the processing plant with a specific end goal to make an adaptable and versatile assembling frameworks and through-designing coordination over the whole esteem affix to empower customization of the item. The interest for high-individualized items and administrations is consistently expanding.

Accordingly, inbound and outbound logistics need to adjust to this evolving condition. Because of its expanding complexity nature, it can't be dealt with normal arranging and control rehearses. "Smart Logistic" is a logistics framework, which can improve the adaptability, the acclimation to the market changes and will influence the organization to be nearer to the client needs (D. Uckelmann, 2008).This will influence conceivable to enhance the level of client to benefit, the improvement of the creation and make bring down the costs of capacity and generation.

As the "Brilliant Logistics" will change in like manner to the real innovation driven, it has a period reliance and along these lines it is fundamental to characterize the cutting edge of the innovation. When all is said in done, clients have a tendency to acknowledge new advancements with finish nonchalance of their characteristic security vulnerabilities, in the event that they get adequate advantages from them (In J.P. Müller et. al., 2015).

Cultivating and constantly reassuring a security culture and perceiving that every single mechanical application and frameworks have their intrinsic vulnerabilities and that individuals still are, and will dependably be the weakest connection, will unquestionably help associations to accomplish their sufficient levels of security and in this way it will build sustainability.

IV CUSTOMER EXPECTATION

Customer expectation is related to the level of satisfaction that can be acquired through excellent customer service.

Knowing who the customers are and their requirements will lead to measuring their satisfaction towards the expectation. Meeting customer's expectation from the logistics supplier's perspective is the ultimate factor that every logistics service providers must consider and strive to achieve. In meeting customer's expectation, one of the most important elements to be considered is cost reduction and this element can be realized when technology is incorporated in the operational aspect.

As Limbourg, S et. al., (2016) mentioned, usage of ICT reduces cost of transaction hence improvising logistics cost. 3D printing technology that became more visible in 2005 has become a catalyst to cost efficiency which is a main factor of expectation from a customer's point of view. Shipping cost is set to be reduced tremendously as 3D printing creates an opportunity for people from all walks of life to create the products that they require through self-customization at the comfort of their home. Products will no longer be required to be shipped through the usual supply chain which consists of supplier, manufacturer, distributor, wholesaler, retailer and finally to end-user.

This customization process will eventually drive the logistics cost to a minimum as inventories will not be required due to its character as a disruptive technology in contrast to manufacturing concern (Feldmann, C., & Pumpe, A. (2017). Another visible factor that 3D printing technology contributes to customer's expectation with regards to improvisation of logistics cost is the elimination of made to stock concept. This cost driver is totally eliminated as a result of personal customization features in 3D printing. This feature is further enhanced through the knowledge and creativity that today's generation possess. 3D printing further eliminates made to stock activity by increasing logistics cost efficiency hence increasing customer satisfaction which leads to the fulfillment of customer's expectation eventually (Kapetaniou et. al., 2018).

V COLLABORATIVE INNOVATION

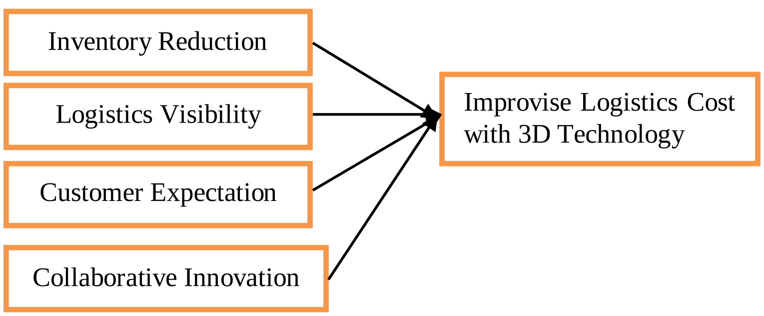
Innovation and research and development (R&D) is vital for any product or service oriented organization pursuing excellence in their respective areas. Numerous developments have contributed to companies innovating and developing their products and services from different perspectives. There are several factors that push firms towards collaborative innovation. Among contributing factors include migration of skilled workforce, private venture capitals flooding the markets, and also due to innovation processes have become more decentralized as a result of technological complexity and fragmentation, internationalization requirements, rapid change, intense competition, and the higher costs and risks (Pia Hurmelinna-Laukkanen, 2011).

However, one of the most obvious consequences for businesses to constantly innovate is the increased participation of users in the production process. Such has been their influence that products and services continuously change features and shape due to demands from customers. Mass customization is no longer feasible due to the short life span of products on the shelf. 3D printing has shifted the balance by allowing niche customization that caters to specific needs of customers. Indeed, with 3D printing technologies, the role of consumers in the production process of physical objects ceases to be peripheral and limited to minor contributions, but becomes central in the production process due to the need of serving niche segments (M.K. Poetz, M. Schreier, 2012).

The question arises on how does the logistics industry deal with such disruptive changes involving the whole supply chain? Transport Intelligence predicts massive shifts in the logistics industry due to 3D printing technology. It will lead to the decline in the shipping and air cargo volume. The transportation cost saved is incredible. Jin et al, (2014), mentioned that global freight volume reduction will be glaring; the level of inventory will also decline. This is because 3D printing can improve the efficiency of the production as needed. Lower transportation and warehousing business will force logistics enterprises to transform. That includes merging 3D printing into logistics activities, focusing on 3D printing material logistics and developing the supply-chain control tower business. As such, collaborative innovation is a must between the manufacturers and logistics services to align business strategies that would cater for the disruptive positive changes taking place due to the manufacturing processes.

VI THEORETICAL FRAMEWORK

We can see that logistics was and is in a continuous change, change influenced by a number of factors in the political, economic and social, technological, environmental and legal environments. The company culture, the need for evolution, means and possibilities of the organizations they had at that moment put their mark on the development of logistics since ancient times (Lee, S.M., Olson, D.L., Trimi, S., (2012). Thus, this research develops and explores a set of theoretical framework to gauge the performance of 3D technology towards the Industrial 4.0 which is highlighted below:



Current literature available does not entirely showcase the effects of 3D printing towards reducing logistics costs as a whole. There have been influxes of opinions suggesting the disruption 3D printing could cause to an entire supply chain. This study has identified 4 major themes emerging that could possibly alter the logistics industry and has been discussed in the literature review section. The study thus aims to enhance this concept in the near future by applying an empirical analysis to further verify the importance of 3D printing in the manufacturing sector and the effects this may cause the logistics industry. As Malaysia joins the global 4.0 industrial revolution, the ever demanding changes occurring through technology infusions and innovations proves to be a credible area worth exploring through the logistics industry.

VII CONCLUSION

This article emphasizes on 3D printing technology. Four variables have been identified in this research. 3D printing, a by-product of industry 4.0 decreases the cost of supply chain especially for tailor made products and goods that are slow moving and exhibits logistics visibility. Performance is optimized through inventory cost reduction and customer expectation is improved in many ways through 3DP technology. As such, these 4 variables had been identified as potential elements which could alter the landscape of logistics industry. The researcher's aims to explore this study further by evaluating and analyzing industry experts views to this phenomenon. As such, an empirical study will be developed to further look into this area of study which shows promising signs for academic and managerial benefits.

VIII ACKNOWLEDGMENT

We wish to thank and acknowledge UTAR for providing us this platform.

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