# Web-based Networking Process of Supply Chain in Additive Manufacturing

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## Abstract

Additive Manufacturing (AM) plays a significant role towards moving forward in the digitization of manufacturing and supply chain. Additive manufacturing is a type of on-demand product manufacturing that employs 3D digital design, software, and hardware to accurately deposit layered materials. Customized products are becoming increasingly important due to change in customer expectations, market needs and sustain in a competitive business environment. In our country's perspective, there are some limitations in the 3D printing process. Like here sometimes the transportation cost is higher than the product cost because of the centralized delivery system. For that reason, low priced products also end up with higher prices due to addition of transportation costs with the product where the product is delivered from one hub to different districts of the country. On the other hand, this also increases the lead time which reduces customer satisfaction. As a result, customers are unwilling to order and additive manufacturing is being neglected. We made a web-based platform where customers can order small size 3D products to a customized version at nearer manufacturers like bookmarks, go pro mount, toy products, drone parts, cycle parts, cookie cutter etc. Customers can find the nearest local manufacturer in our network of local industries through our website and place the order. Then the product will be delivered from that nearest manufacturing unit to the customer directly. As this is a make to order process, there will be minimal inventory of the final product too. In

this paper we have built up the network of various district's manufacturers and customers. The supply chain is improved with improving customer satisfaction through delivery of products by additive manufacturing process, reduced lead time, lowered transportation cost.

## Keywords
Web-based platform, 3D printing, Customized product, Local manufacturing network, Digitalization

## 1. Introduction
Additive manufacturing involves the use of digital product design and the process of connecting layers of materials to the produced product and adding layers to it (ASTM,2012). AM is generally used to produce individual products and small batches (a unit batch). This helps to automatically reduce the time it takes for the product to be delivered to the end user (GAO et al., 2015). Increasing demand for customized products, shortening delivery cycle, requirements for additional services pose new challenges for industrial manufacturing (Bringer and Warneck, 2003). In today's rapidly changing modern manufacturing environment, additive manufacturing includes a technology platform that can manufacture customized products "on demand". For Production-Centric Consequences, AM also announced SC upstream and downstream transactions (Weller, Kleer and Piller 2015) and provide potential for shorter, simpler and more collaborative value networks (Gebler, Uiterkamp and Visser 2014). Supply chain management (SCM) is all business entities which covers the planning, logistics design, implementation and control of company activities, including procurement, inventory control, manufacturing, distribution (Attaran 2017c). In the future, business processes and supply chains will become more complex, even more without proper control (Rodenhäuser and Rauch, 2015).
There are signs that companies are not fully exploiting the benefits of AM. This research chain of supply consists of a network of companies that transmit and process materials and information to each other. (Heikkilä2002). AM characteristics, including improved product-level integration, can enable easier supply chains. Multiple functions can be improved through the integration with AM like lead time, inventory and cost reduction (Holmströmet al., 2010). AM offers SMEs the possibility of new development and creates more cost effectively specializes in specific production areas or customized products (BMWI, 2019). Flexible and market-responsive supply chains are also needed to reduce delay (Fisher et al., 1997). AM technology increases supplier-customer collaboration. The SCM is now considered the heart of the company's strategy, especially because of commercial competition (Lambert, 2017). Therefore, it is already possible to identify different opportunities to integrate digital trends through additive manufacturing, big data and augmented reality, which will affect its configuration and performance (Ivanov,2019).
AM is still not having proper popularity due to its improper networking system. Customer does not find it user friendly due to its lack of responsiveness. Moreover, small additive manufactured products are sometimes having more delivery cost than the original price of product. These things are keeping customers away from adopting the AM technology. The objectives of this research is to create a web-based platform that will ease the ordering process including a make to order process with providing a system to order from the nearest manufacturer to that customer, reducing transportation cost and lead time which helps to improving the responsiveness of supply chain. A website based ordering system can help to increase customer expectation because from this platform they can find their own district manufacturer & their product list. Besides that, customers can also place an order for their desired customized product.

## 2. Research Methodology
Supply chain operation model consisting of three links: suppliers, Manufacturer or assembler, and distribution network which corresponds to a representation of Make-to-order (MTO) system; that is, production will only start when demand arises. MTO modes respond to customer needs, allowing for more customization while reducing inventory time that includes characteristics of additive production modified manufacturing, which can be found in traditional manufacturing. Simultaneously, due to acceptance capacity and raw material inventories, they cause an increase in demand response time [Hedenstierna, 2019]. When the order is received, the producer evaluates their production capability and creates purchase orders for raw materials in order to begin production. Because the inventory level approaches zero, suppliers are used, and variables such as response time, cost, and quality are considered. The number of orders placed and the number of deliveries made are examined. The transformation cycle then begins.
In this research, a web-based platform has been created allowing users to order small-scale 3D items with customization facility. In this website, manufacturers are listed by division, with product descriptions, prices, and images. The ordering process has been illustrated in figure 1 to describe the ordering process:

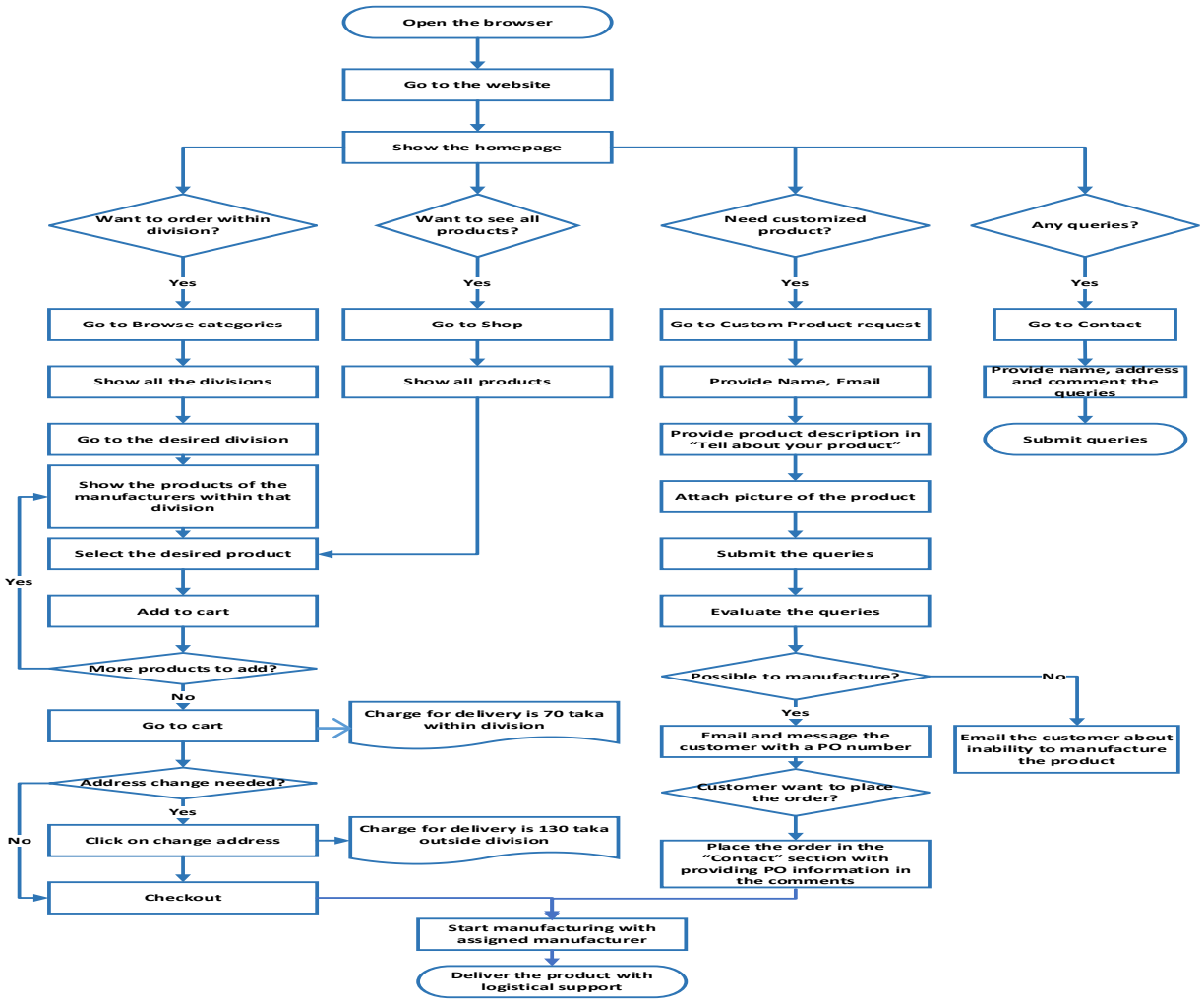


Figure1: Framework of website ordering process

In this project, a website (https://superstruct3d.com) has been constructed to put this structure into action which is shown in figure 2 and 3. Figure 2 shows browse categories and custom product request features. There are eight divisions in our website's browse categories, as well as a shop option that contains all of our manufacturer's products. We can add different district manufacturers so that clients may order products from the ones that are closest to them. In our website, we have added three manufacturer's products in Dhaka, Chittagong and Mymensingh divisions.

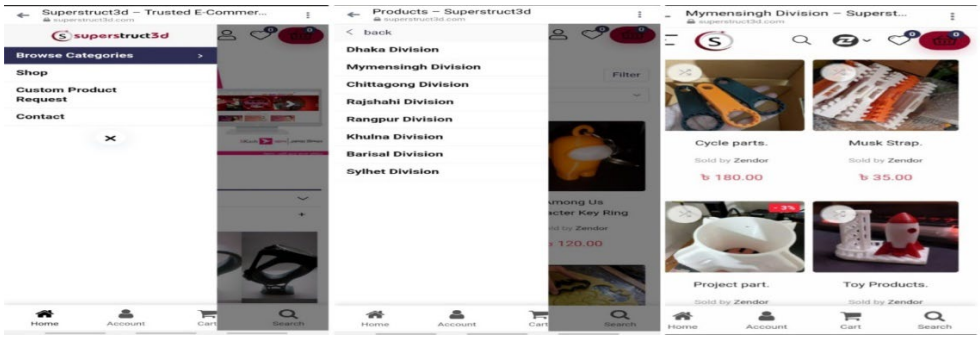


Figure 2: Browse categories, divisions and shop

Figure 3 shows custom product request and contact options. In custom product request option, customer can customize their product's design according to their own choice and they can upload pictures if they have. In the contact section, customer can ask questions if they have any queries.

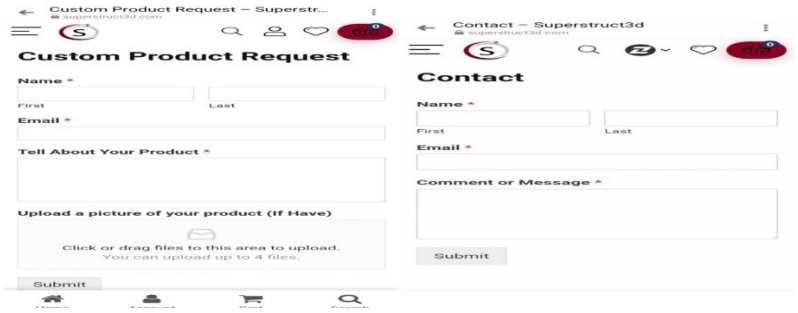


Figure 3: Custom product request and contact option

The manufacturing procedure will begin once the order has been confirmed. The product will be distributed by a third party in their appropriate district at the end of the process.

## 3. Data Collection

### 3.1. Before implementation

Before implementation of our process, all the given data were collected from three 3D printing manufacturers and they are from Dhaka, Mymensingh and Chittagong. They provided us with a list of their products, prices, delivery cost and delivery location which are shown in table 1.

Table 1: Product, Lead Time and Delivery Information (Before)

| Order Number | Product Name | Manufacturer area | Delivery Area | Quantity | Product price(tk) | Delivery Cost(tk) | Lead time(days) |
|---|---|---|---|---|---|---|---|
| 1 | Musk strap | Mymensingh | Sylhet | 200 | 35 | 130 | 3 |
| 2 | Go Pro Mount | | Mymensingh | 1 | 200 | 70 | 2 |
| 3 | Project Parts | | Dhaka | 1 | 350 | 130 | 3 |
| 4 | Cycle Parts | | Rajshahi | 1 | 180 | 130 | 2 |
| 5 | Custom Parts2 | | Mymensingh | 1 | 300 | 70 | 1 |
| 6 | Dron Parts | Chittagong | Jamalpur | 3 | 134 | 130 | 3 |
| 7 | Toy Produsts | | Dhaka | 1 | 380 | 130 | 3 |
| 8 | Cookie Cutter | | Chittagong | 3 | 200 | 70 | 1 |
| 9 | Bookmark | | Khulna | 1 | 80 | 130 | 2 |
| 10 | Go Pro Mount | | Chittagong | 1 | 140 | 70 | 1 |
| 11 | Thumbs Up Light Lamp | Dhaka | Dhaka | 1 | 300 | 70 | 1 |
| 12 | Watch Holder | | Barisal | 1 | 150 | 130 | 4 |
| 13 | Money Heist Mask Strap | | Sylhet | 1 | 30 | 130 | 3 |
| 14 | Among Us Character Key Ring | | Dhaka | 1 | 120 | 70 | 1 |
| 15 | 3D Printed 775 Motor Pump Kit | | Jamalpur | 1 | 210 | 130 | 2 |

The necessary data were analyzed including product price and delivery costs. For comparing product price and delivery costs, a graphical representation was used that is shown in figure 4 it can be observed that the transportation cost was higher than the product price when they delivered small sized products from one district to another district because of the centralized delivery system. In this case, the waiting period was also prolonged.

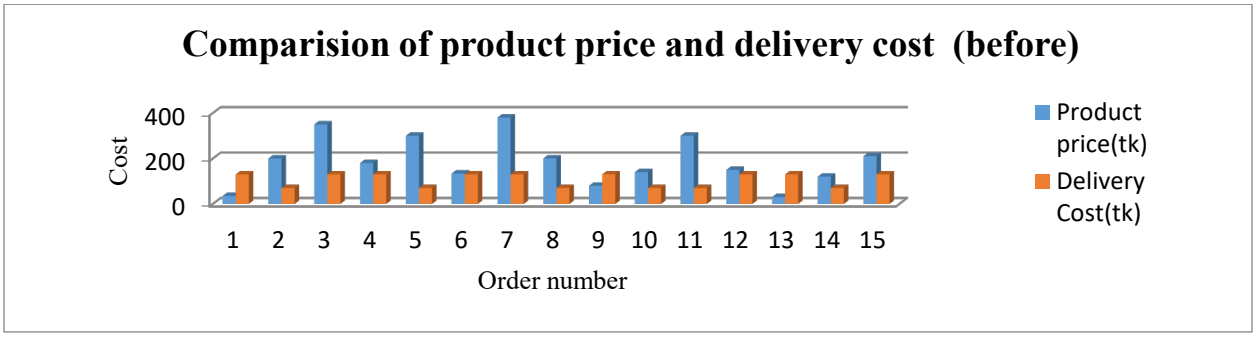


Figure 4: Comparison of product price and delivery cost (before)

### 3.2 After implementation

In this section we discuss about the implementation of website based process. The following information was gathered in order to reduce lead time and delivery costs. Customers placed orders with the manufacturers in their particular district that is shown in table 2.

Table 2: Product, Lead Time and Delivery Information (After)

| Order Number | Product Name | Manufacturer area | Delivery Area | Quantity | Product price(taka | Delivery Cost(taka) | Lead time(days) |
|---|---|---|---|---|---|---|---|
| 1 | Musk strap | Mymensingh | Muktagacha | 100 | 35 | 70 | 1 |
| 2 | Go Pro Mount | | Gouripur | 3 | 200 | 70 | 1 |
| 3 | Project Parts | | Valuka | 1 | 350 | 70 | 1 |
| 4 | Cycle Parts | | Rajshahi | 2 | 180 | 130 | 2 |
| 5 | Custom Parts2 | | Fulbaria | 2 | 300 | 70 | 2 |
| 6 | Dron Parts | Chittagong | Hathazari | 5 | 134 | 70 | 1 |
| 7 | Toy Produsts | | Halishahar | 2 | 380 | 70 | 1 |
| 8 | Cookie Cutter | | Khulna | 3 | 200 | 130 | 1 |
| 9 | Bookmark | | Pahartali | 2 | 80 | 70 | 2 |
| 10 | Go Pro Mount | | Khulshi | 3 | 140 | 70 | 1 |
| 11 | Thumbs Up Light Lamp | Dhaka | Mirpur | 1 | 300 | 70 | 2 |
| 12 | Watch Holder | | Sylhet | 2 | 150 | 130 | 1 |
| 13 | Money Heist Mask Strap | | Rampura | 4 | 30 | 70 | 1 |
| 14 | Among Us Character Key Ring | | Farmgate | 3 | 120 | 70 | 1 |
| 15 | 3D Printed 775 Motor Pump Kit | | Motijheel | 1 | 210 | 70 | 1 |

After compiling information from the website, it was discovered that the maximum delivery cost decreased as a result of people ordering from their local manufacturer. Due to unavoidable circumstances, some delivery costs were not reduced. For comparing product price and delivery costs, a graphical representation was used that is shown in figure 5.

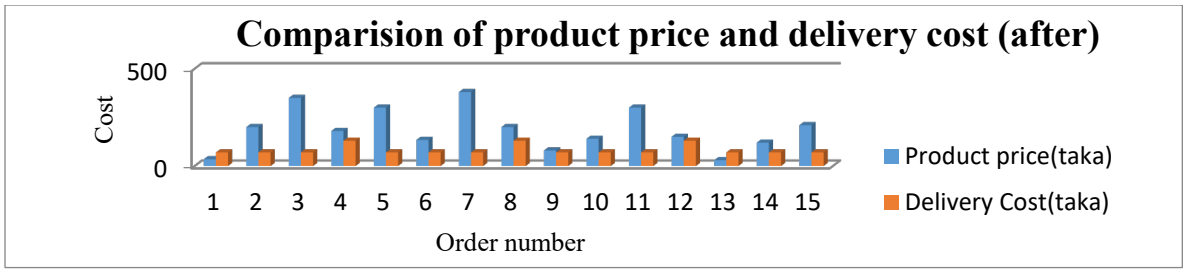


Figure 5: Comparision of product price and delivery cost(after)

## 5. Results and Discussion

Here the delivery cost and lead time of before and after were compared in figure 6. In this case study fifteen orders were picked based on delivery area, lead time and delivery cost, then those delivered orders were re-collected according to this process. The result shows an optimal value to decrease the lead time and delivery cost.

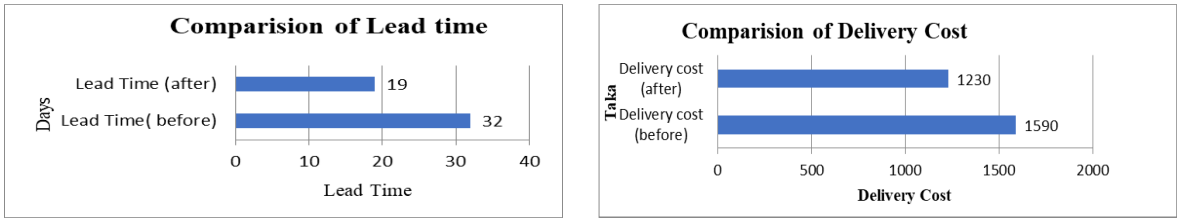


Figure 6: (a) Comparison of before and after lead time and (b) delivery cost

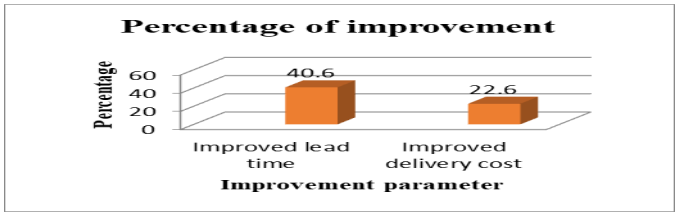


Figure 7: Improvement of lead time and delivery cost

The delivery cost and lead time of before and after were compared. Before the research lead time was 32 days and delivery cost was 1590 taka. But after applying our website based process lead time was 19 days and delivery cost was 1230 taka. So the lead time was improved 40.6% and the delivery cost was improved 22.6%. Companies must be more responsive in today's highly competitive world markets in order to meet customer demands quickly. Industrial companies must continually improve their efficiency to maintain long-term progress and profitability in a competitive market environment (Sudit 1995). In this paper, responsiveness has been well established and efficiency has also increased.

## 6. Conclusion

The successful deployment of a new technology is influenced by market demand and supply chain aims and structure. In this paper, we have provided a website based solution for customer satisfaction. Customer satisfaction is improved as a result of the additive manufacturing process's delivery of high-quality items, shorter lead times, lower shipping costs, and lower inventory costs.

- The approach was to create a network between customers and manufacturers and the method worked well in terms of decreasing transportation costs and reducing lead times.
- Based on the findings, it is estimated that by implementing the method, the lead time was improved 40.6% and the delivery cost was improved 22.6%.
- Basis of the results, it is estimated that applying the approach to the entire delivery system will have a positive influence on the 3D printing shop's delivery cost and lead time, as these are simple to use to discover the most optimal output in a dynamic environment.
- In fact, we may expect to see these technologies used and expanded in a variety of industries, such as 3D printing, online stores, and other retail chains, to reduce transportation costs, decrease lead times, and improve customer satisfaction by adding local district manufacturers.

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## Biography

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