THE DISRUPTIVE FORCE OF 3D PRINTING ON SUPPLY CHAINS

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Abstract
Considered by McKinsey one of the disruptive technologies that will change the way of manufacturing, 3D printing is a method widely used in design and prototyping. This method can have a great impact on the supply chain as soon as it will be used in manufacturing, as companies will be able to manufacture on their own and very quickly what is now realized by a wide series of subcontractors. This article has as its goal to discover if indeed 3D printing will very soon restructure the supply chains and in what way.
Keywords: Supply chain management, Disruptive forces, 3D printing, Additive manufacturing.

1. INTRODUCTION

Since 2012 a lot of very serious international journals and magazines have been heading that a new industrial revolution is about to come. The Economist, 'A third industrial revolution', The Wall Street Journal, 'A revolution in the making', Harvard Business Review, '3D Printing will change the world', are only some of the titles that readers could discover. Time magazine even put the subject directly on the cover of the April 22, 2013 issue with a big statement: Made in the USA. All these articles are talking about a new way to manufacture goods, the 3D printing. If this is, in fact, the case and this new technology can actually impact so much manufacturing, the logic inference would be that 3D printing will also affect supply chain in an important way.

An industrial revolution, as it is named by the different journals above, marks a major turning point in history as it represents the transition to new manufacturing processes, influencing in some way almost every aspect of daily life (Wikipedia, 2015a). The industrial revolution is brought about by new technologies for which researchers spend even years in laboratories with the hope that their inventions will revolutionize how things are produced. Because they know that an organization becomes competitive if it manages to create competences that generate positive effects through innovation (Corboş and Popescu, 2013). The innovation appears in goods, as well in services, knowing that

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recently, services turned out to be the main dynamic component of economic competition (Zamfir and Corbos, 2012). Therefore, services in this field should not be neglected (Zamfir, 2010). But very few of the innovations discovered have the power to really bring about a new industrial revolution. Nevertheless, the excellence in business, especially in industry must always be looked-for (Verboncu, 2013).

Big consultancy companies like McKinsey and PWC consider this technology as one that will shortly disrupt the manufacturing processes. In a 2013 report on disruptive technologies, McKinsey stated that 3D printing will not only improve manufacturing but also reduce the amount of waste (McKinsey Global Institute, 2013). Also, in June 2014, one of McKinsey's directors stated that 3D printing will also have a great impact on supply chain (Niemeyer et al., 2014). PWC realized a study on the impact of 3D printing on manufacturing, one of the outputs being the fact that professionals think that this technology can disrupt the most the manufacturing systems by restructuring the supply chains (PriceWaterhouseCoopers, 2014).

2. DESCRIPTION OF 3D PRINTING

Shortly named 3D printing, this technology is also known as additive manufacturing, defined by a range of technologies that are capable of translating virtual solid model data into physical models in a quick and easy process, through a 'What You See Is What You Build' process (Gibson et al., 2010). There are several types of 3D printing technologies: SLA – stereolithography, FDM – fused-deposition modelling and SLS – selective laser sintering (Miller, 2014). SLA, or stereolithography, is an additive manufacturing technology that produces objects by adding up layers of material with the aid of a laser (Wikipedia, 2015b). This method was first developed by Charles Hull in 1984, patents were obtained during the 1990's and started being widely used for prototyping during the years 2000 (3d-innovations.com, 2012). FDM or fused-deposition modelling is a technology in which the printers melt a plastic filament and deposit the plastic in layers until it creates the model and the SLS or selective laser sintering uses powdered metal which is sintered using layers (Miller, 2014).

Nowadays, 3D printers are used to manufacture very quickly objects made of plaster, bioplastic, polyurethane, polyester, epoxy, metal and other substances, based on a model captured in a computer file. The software used by 3D printers is a 3D CAD one that measures thousands of cross-sections of each product to determine exactly how each layer is to be constructed (Berman, 2012). This method is used mainly in fields like medicine, architecture and in industries using prototypes in order to manufacture their products (3ders.org, 2015).

One of the most important barriers in adopting a new production technique is the price. While when they appeared, a stereolithography machine would have been sold at around 100,000$ or more (Hoffman, 2011), nowadays we can find 3D printers ranging from 100-200$ to around 50,000$, only the most complicated arriving at more than 100,000$ (3ders.org, 2015). Prices for raw materials are also affordable, ranging in the couple of tens of dollars (3ders.org, 2015).

3D Printers are now at hand for everyone who is interested in manufacturing at home their own personalized products, as MicrosoftStore.com is selling MakerBot Replicators at prices starting at $1,375 (microsoftstore.com, 2015). Interested people, passionate or with no skills at all, can share and find computer files with models for 3D printing. Websites like Thingiverse.com allow you not only to download models for products that you can use on a 3D printer but also to upload your own models and share them with others. Only on Thingiverse one can find no less than 100,000 3D models uploaded by a big community of users (thingiverse.com, 2015). The competence and performance of the individuals sharing their models may lead to the performance of the entire society (Corbos, 2005). Also, in the United States, big companies like UPS and Staples offer 3D printing services for the clients who are not interested in spending amounts of money on printers. Last year, UPS announced that, following the success known by the installation of 3D printers in 6 stores around US, they will propose the same service in nearly 100 additional locations nationwide, together with Stratasys (ups.com, 2014). Last year also, Staples announced a partnership with 3D Systems to pilot this kind of services in two stores in New York City and Los Angeles, where consumers and small businesses can create personalized products and use 3D printing hardware (investor.staples.com, 2015).

Seeing the advantages of 3D printing and the fact that almost every company could afford to buy a machine worth a couple of hundred dollars, we can reach the conclusion that this method will very quickly be used in many fields of work and will change the ways in which businesses are conducted. In fact, the industry of 3D printing is rapidly growing as figures show. Consultants measured the size of the industry and found that in 2008 the global market for additive manufacturing was around $1.2 billion (The Economist, 2009) and in 2013 reached $2.5 billion. Also, the research corporation Canalys predicts a market of around $16.2 billion by 2018 (canalys.com, 2014). The American 3D printing industry, the most important in this field of work, is characterized by many 3D printer companies, but two of them cover 37.9 % of the market: 3D Systems Corporation (19.5%) and Stratasys Inc. (18.4%) (Crompton, 2014).

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3. APPLICATION OF 3D PRINTING IN MANUFACTURING

A study made by The Freedonia Group in 2013 on world 3D printing stresses that while prototyping will still continue to account for the majority of demand, the more rapid growth will be seen in production and consumer applications (Freedonia Group, 2013).

An independent research organization from Netherlands, TNO, published a white paper in 2014 presenting the advantages and drawbacks of 3D printing. They found that this method can be used for economical product customization and complex product manufacturing and also when manufacturers needed freedom of design. Furthermore, 3D printing can be used to manufacture in any location, thus providing decentralized manufacturing. The drawbacks of this method are: limited product dimensions, reduced choice for materials, lower precision and limited strength (Janssen et al., 2014).

In fact, 3D printing allows companies to manufacture custom products in small quantities and, sometimes, at smaller prices than mass customization. The nowadays environment is characterized by the fact that manufacturing must adapt to the actual demand of each buyer and have the flexibility for this goal (Mirea and Babalac, 2014). Although additive manufacturing can't make an iPhone yet, it can produce a customized cover for it (The Economist, 2012). 3D printing can also be a better form of production in contrast to injection molding processes that require costly molds and can generate less waste material (Berman, 2012). Also, there are products that cannot be manufactured the traditional way, using milling and casting, but that could come to reality using additive manufacturing (Koten, 2013). Known also as direct digital manufacturing, many applications considered impossible, infeasible or uneconomic in the past can come to life (Gibson et al., 2010).

3D printing changes the manufacturing paradigm by replacing the competitive dynamics of traditional economies-of-scale production with an economies-of-one production model. Traditional manufacturing relies on a design-build-deliver model, where companies would become successful if they achieved high-quality products at the lowest cost. The additive manufacturing system will affect the design-build-deliver model in three ways: changing the nature of design, as even the client can become the designer of the product manufactured, changing the relationship between how a product is conceived, manufactured and tested, and changing the traditional distributed supply chain (Petrick and Simpson, 2013).

For the moment, 3D printing is still widely used for prototyping but many of the companies using this technology for this end realized that they can also use it for finished products, like BMW, which is now extending the application to other areas and functions, like direct digital manufacturing (stratasys.com,

2015). Other example is given by GE, a company that intends to make a sophisticated nozzle for their next-generation jet engine, that will be 3D printed as a single part rather than assembled from 18 pieces, and it will be up to five times more durable (Koten, 2013).

An important issue related to using 3D printing for manufacturing almost everything is related to the implications for intellectual property security. The availability of CAD design software descriptions on the web allows the easy copying of the design and the reselling (Berman, 2012). Also, some ethical questions should arise, as human body parts or guns can be also manufactured with 3D printing (Miller, 2014).

4. IMPACT OF 3D PRINTING ON SUPPLY CHAIN

We have seen that this industry is already important and that it's starting to affect the manufacturing, but in order for it to have a big impact on the supply chain system, it should be widely used in producing not only prototypes, but also finished products. 3D printing can affect the supply chain as companies will not be bound to have the finished products stored on shelves or in warehouses anymore (Intrieri, 2014).

A first implication of 3D printing is that businesses will have to rethink their strategies and operations all along the supply, manufacturing and retailing chains (D'Aveni, 2013). The business model based on economies of scale was characterized by products obtained at the lowest cost, due to big volumes. Even if this was possible only by producing in countries situated far from the place of consumption, the cost of the transportation was outweighed by distributed supply chains and the low cost of production. With this new form of manufacturing, the production place can drastically change and come nearer the end consumer. Consumers interacting with producers will bring changes to the traditional distributed supply chains. Firstly, the place of production changing, there will be no need for transportation in big containers and for a complex supply chain moving products around the globe and storing them in warehouses. The production will need only raw materials, which will be delivered in small parcels. Also, distribution will be affected by the appearance of printer hubs, disrupting thus the economies-of-scale model (Petrick and Simpson, 2013).

Supply chain will also be affected if 3D printing is used to replace mass customization, which requires a high degree of supply chain integration. Mass customization uses, as raw materials, the component parts to be integrated, while companies using additive manufacturing will be obliged to provision raw materials as plastics, resins, alloys and other materials used to manufacture this new way (Berman, 2012).

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An industry which relies much on the supply chain is the automobile industry, which is based on an important series of subcontractors. This industry relies on a solid supply chain system, and a flaw in this system can have an ill impact on the activity. The customer satisfaction is very important in this industry and if it's pursued within a quality-oriented approach, the chances to have a satisfied customer are greater (Silvestri, 2014). The case of Toyota is well-known, as the increasing rate of recalls over the years 2000 was due to non reliable products from tier-two and tier-three suppliers (The Economist, 2010). 3D printing could help reduce the importance of this kind of suppliers, and as we have seen before with the case of BMW, the players of this industry are beginning to introduce this technology.

Supply chain can also be affected by the decision of the manufacturing companies to start producing elements that are now outsourced, leading to an integration strategy, seen as the unification of production, distribution, sales and/or any other economic processes within the same organization (Corbos, 2011).

5. CONCLUSION

3D printing can clearly have an impact on supply chain management, defined as the system focused on the integration of suppliers and customers to achieve an integrated value chain with the help of information technologies and systems (Gunasekaran et al., 2008). The implications of using this method will be that the supply chain will ensure the procurement and storage of raw materials instead of spare parts. But the drawbacks of the method and these implications, which can change drastically the way of doing business, are for the moment factors that prevent the 3D printing from becoming a really disruptive force for the supply chain.

Even if for the moment a little percentage of users of 3D printers employ this technology for finished products, as this method is still largely used for design and prototyping, in the near future the advantages of additive manufacturing will impose themselves in manufacturing and will also affect supply chains drastically.

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