The Impact of 3D Printing on Manufacturer-Retailer Contractual Relationships

3D printing, also known as additive manufacturing, is an alternative manufacturing technique that is based on producing a product layer by layer. This technique contrasts with traditional manufacturing techniques, such as milling, forging, and welding. 3D printing has received significant and growing attention in recent years by different countries. President Obama’s 2013 State of the Union address (Gross 2013) is perhaps the most prominent one. In addition to the United States, other countries such as Japan, India, France, China, Netherlands and Belgium are investing in 3D printing. Furthermore, prominent manufacturers and manufacturing industries, that have historically utilized traditional manufacturing techniques, are also adopting 3D printing technology. General Electric and Disney are two major instances.

Conner et al. (2014) propose a framework that attempts to understand where 3D printing is economically feasible. They explain that the key attributes of a product are its complexity, customizability, and production volume; they unify these three characteristics into a Modified Complexity Factor (MCF). They argue that 3D printing is likely to have a lower unit production cost than traditional manufacturing techniques if the MCF is high, which occurs with high complexity, and/or high customizability, and/or low production volume. Our research is motivated by the products where 3D printing can provide a more economical unit production cost than traditional manufacturing techniques.

According to a Gartner poll, 65 percent of supply chain professionals aim to invest in 3D printing during the next five years (Alec 2016). Therefore, in our research we propose and analyze stylized game-theoretic models of a simple manufacturer-retailer supply chain for a single product, where 3D printing is available. We first consider the natural case where the manufacturer may purchase a 3D printer to supplement/replace traditional manufacturing techniques; we show that, if the acquisition cost of the 3D printer is below a threshold, the manufacturer is better off by purchasing the 3D printer. We also introduce a novel arrangement where the retailer may purchase the 3D printer,
with possible encouragement, in the form of a subsidy, or determent, in the form of a fee, from the manufacturer; the manufacturer can still sell products produced using traditional manufacturing techniques, but also has the option of selling to the retailer the 3D printing instructions and the right to print a predetermined number of products. It is uncommon for a retailer to use traditional manufacturing techniques, and we see the possibility of a retailer 3D printing products as a unique feature. As in the previous case, we show that if the 3D printer cost is below a threshold, the retailer will purchase the 3D printer.

We utilize two natural benchmarks to evaluate the impact of the 3D printer on the supply chain: 1) a decentralized system with no 3D printing and 2) a centralized system with 3D printing. Comparisons with 1) show us that a manufacturer-purchased 3D printer results in both firms earning at least as much profit as the benchmark case. Comparisons with 2) lead to a surprising result: a manufacturer-purchased 3D printer results in the double marginalization effect being reduced, but not eliminated, whereas a retailer-purchased 3D printer results in the elimination of the double marginalization effect. Therefore, a main contribution of our research is that the unique features of 3D printing, combined with a retailer purchasing the printer, result in a new mechanism for supply chain coordination, which further increases the appeal of this new manufacturing technology.

Another recent Gartner (2014) survey reports that high acquisition cost are a main factor delaying a firm’s adoption of 3D printing; our analytical results, which show adoption occurring when the printer cost is below a threshold, are consistent with these results. However, given that there are many governments interested in investing in and subsidizing 3D printing, as mentioned above, we also explore the role of government subsidies to encourage firms’ adoption of this new technology. We do so for both manufacturer-purchased as well as retailer-purchased 3D printers.

The following is a summary of our main contributions to the operations management literature. (1) To the best of our knowledge, we are the first to analyze the impact of 3D printing on a supply chain. The unique characteristics of 3D printing result in its potential adoption by either the manufacturer or retailer, resulting in new models of cash, material and information flows. (2) We
characterize the economic conditions that induce a manufacturer to adopt 3D printing, which lead to improved profit outcomes for both the manufacturer and retailer. While the double marginalization effect is diminished, it is not eliminated. (3) We characterize the economic conditions that induce a retailer to adopt 3D printing, which results in the manufacturer charging the retailer a fixed fee for the right to print as many products as desired. Also, the double marginalization effect is eliminated, demonstrating that retailer 3D printing can be a mechanism for coordinating a supply chain. (4) The economic conditions for either firm to adopt 3D printing, under a uniform distribution of demand, are shown to be upper bounds for the acquisition cost of a 3D printer. If this cost is too high, the firms will not naturally adopt this new technology, and we consider the influence of a government subsidy to entice adoption. We derive the minimum cost subsidy to induce adoption for either firm, and we find that the retailer subsidy is always lower.

References


