ABSTRACT

Research is needed regarding adoption of 3D printing especially among logistics organizations since recent reports tout that it is the largest industry impacted. Two research questions are addressed: how does the organizational innovation adoption category impact 3D printing adoption, and how do the perceived characteristics of 3D printing impact adoption? Structured interviews from logistics professionals and archival data findings show an organization’s innovation adoption category not only impacts intention to adopt 3D printing, but also the rate of adoption. Moreover, results show that relative advantage, compatibility, trialability, observability and image greatly enhance 3D printing adoption among each innovation adoption category.

KEYWORDS: 3D printing, Additive manufacturing, Adoption
ABSTRACT

Research is needed regarding adoption of 3D printing especially among logistics organizations since recent reports tout that it is the largest industry impacted. Two research questions are addressed: how does the organizational innovation adoption category impact 3D printing adoption, and how do the perceived characteristics of 3D printing impact adoption? Structured interviews from logistics professionals and archival data findings show an organization’s innovation adoption category not only impacts intention to adopt 3D printing, but also the rate of adoption. Moreover, results show that relative advantage, compatibility, trialability, observability and image greatly enhance 3D printing adoption among each innovation adoption category.

KEYWORDS: 3D printing, Additive manufacturing, Adoption

INTRODUCTION

3D printing is an additive manufacturing process in which material is added or layered to produce a product (Waller and Fawcett 2014). Unlike traditional production which relies on subtractive processes (or taking material away), 3D printing layers plastic, metal and a variety of other materials one by one, until a part, component or final product is formed. The history of 3D printing dates back to 1980. However, it was not until the 1990s that the use of 3D printing in manufacturing with rapid prototyping and began to manifest into finished parts manufacturing. While 3D printing continues to grow in both application and research in manufacturing, the growth of 3D printing for logistics is minimal in practice and research is almost nonexistent. Current research in 3D printing is still in its infancy. The majority of research describes benefits to the medical field (Pallari et al. 2010; Hirshfield et al. 2014), engineering (Behdani et al. 2010; Forrest and Cao 2013; Yoon et al. 2014), and manufacturing (Morrow et al. 2007; Baumers et al. 2011; Fogliatto et al. 2012; Huang et al. 2013; Beyer 2014). Minimal research exists on 3D printing in logistics. Presently, there is a focus on various benefits which 3D printing offers that include reduced inventory (Christopher and Ryals 2014; Liu et al. 2014), reduced weights for transportation and energy savings (Beyer 2014), enhanced supply chain responsiveness through make-to-order strategies and customization possibilities (Achillas et al. 2014), as well as speed-to-market (Kleis et al. 2014). These potential benefits of 3D printing solidifies its importance to the logistics industry and spurs the interest of many supply chain professionals. However, 3D printing has been around for decades and still has yet to reach minimal adoption especially among logistics organizations. More research is needed regarding adoption in the logistics industry. Thus, this paper assesses what it is that impacts 3D printing adoption in logistics through investigation of two research questions:

*How does organizational innovation adoption category impact 3D printing adoption?*
*How does the perceived characteristics of 3D printing impact adoption?*
LITERATURE REVIEW

While the adoption of 3D printing for mass manufacturing is still at low levels of exploitation (Mellor et al. 2014) the potential benefits have propelled the interest of many organizations. If manufacturing adoption of 3D printing continues to grow as it has been, the logistics industry is likely to be highly impacted. Impacts of 3D printing to the logistics industry are numerous. Potentially, there will be a reduction in shipping and air cargo volumes as more goods that were once produced in Asian markets might be near-sourced to North America and Europe (Manners-Bell and Lyon 2014). Inventory levels are likely to drop due to mass customization as goods are made-to-order which is likely to reduce warehousing requirements (Liu et al. 2014). Logistics suppliers might find a decreasing involvement in upstream supply chains as manufacturing processes are reduced to single facilities (Christopher and Ryals 2014). Further tiers of component suppliers may also be reduced (Huang et al. 2013). Downstream logistics might also be affected as make-to-order production could impact the manufacturer-wholesaler-retailer relationship (Achillas et al. 2014). In some sectors retailers might be reduced to providing examples for manufacturers but not keeping any inventory stock (Manners-Bell and Lyon 2014).

Given these potential consequences of rapid adoption of 3D printing among manufacturing organizations, many logistics organizations have had to rethink their business strategies, as the looming prospect of 3D printing becomes more of a possibility and potentially widely adopted. For example, The United Parcel Service (UPS) recently adopted and expanded their successful 3D printing services to more than 100 UPS stores nationwide (CNN Money 2014). Based on current projections of 3D printing use in manufacturing (Manners-Bell and Lyon 2014) logistics organizations are faced with an issue of either adoption of 3D printing into the existing business strategy or potentially facing severe impacts to corporate sustainability. Despite these possibilities only recently have large logistics organizations adopted 3D printing and revised corporate strategies. However, regardless of the continued growth and use of 3D printing in manufacturing many logistics organizations are reluctant to consider adoption. Only eight percent suggested that 3D printing plays a role in the logistics industry (Manners-Bell and Lyon 2014). This mindset and reluctance of logistics organizations to consider adoption is potentially threatening for their survival given its increasing emergence in manufacturing. Further, with the potential economic benefits of 3D printing adoption for its potential to enhance near-sourcing (Manners-Bell and Lyon 2014) it is important to understand the diffusion of 3D printing in a variety of industries including logistics.

Limited research on adoption of 3D printing has been conducted. The majority of current studies focus on potential implications of 3D printing assuming widespread adoption (i.e., Ford 2014; Khajavi et al. 2014; Huang et al. 2015). However, adoption even among manufacturing organizations has not yet reached the tipping point for these potential benefits to be realized (Eddy 2014). Thus, more research is needed in adoption of 3D printing, especially in the logistics area which, although it will be one of the first industries affected, still shows reluctance toward the process (Manners-Bell and Lyon 2014).

The generalized paradigm of innovation diffusion is highly expansive and includes a variety of theories tailored to both the adopter of an innovation as well as aspects of the actual innovation itself (Wu et al. 2013). This research focuses on both criteria using innovation diffusion theory (IDT).

The first criterion of IDT specifies innovation adoption categories which help address the first research question. IDT proposes a classification scheme that groups individuals or organizations into several different adoption categories in terms of their reaction to an innovation (Rogers 2003; Yi et al. 2006). These categories include innovators, early adopters,
early majority, late majority and laggards. Innovators and early adopters are those who are ready to take a risk in terms of trying out a new idea over other competitors (Moore 1999; Rogers 2003). These organizations tend to be greater beneficiaries of innovative technologies. However, the innovator organizations tend to have only a slightly higher risk-taking propensity than the early adopters (Yi et al. 2006). Innovators and early adopters share much of the same qualities, and thus, current literature often groups them together (Yi et al. 2006). It is important to note that there are risk-taking propensity differences between these two categories, and so they are given distinction in IDT literature. In this paper we have decided to follow Yi et al. (2006) by grouping innovators with early adopters for the primary reason that none of the respondents indicated a high risk-taking propensity. It can be deduced from this that organizations indicating a strong inclination to stay up to date with the latest technology can be grouped in the early adopter category. However, given the lack of insight regarding risk-taking propensity, innovators are included within this innovation adoption category.

Next is the early majority which are driven by practicality and prefer to witness how other competitors react to an innovation like 3D printing. Well established references play an important role in an early majority’s adoption of innovation (Moore 1999; Rogers 2003). As such if the adoption of 3D printing is perceived to be successful then the early majority is likely to be the next group to adopt 3D printing.

The late majority adopts an innovation like 3D printing when it becomes an established standard. 3D printing would be adopted only if their organization has the ability to adequately handle the technology (Yi et al. 2006). The late majority rely on support from large, well-established organizations including those that manufacture 3D printers. Finally, the laggards tend to be the most cautious about innovations and only adopt when it becomes a necessity.

Now consider another criterion of IDT (the perceived facets of the innovation or 3D printing). IDT defines five different characteristics of an innovation: relative advantage, compatibility, complexity, trialability and observability (Rogers 2003).

Relative advantage is the degree to which an innovation is perceived to be greater than a previously accepted idea. Within manufacturing the relative advantage of 3D printing over traditional subtractive manufacturing is clear with less scrap waist, faster production runs and rapid prototyping (Berman 2012; Achillas et al. 2014; Khajavi et al. 2014; Mellor et al. 2014). The relative advantage of 3D printing to logistics is slightly less clear because it is a manufacturing process. There are various negative impacts which might be considered problematic to the logistics industry. For example, many logistics providers have adopted 3D printing as a means of transforming their own business strategies. Some of the larger logistics providers have gone into 3D printing products for consumers completely bypassing manufacturing (CNN Money 2014). This rapid change from current business strategy may be considered more costly than beneficial to smaller logistics organizations which may not have resources available. However, there are still some organizations such as UPS that are willing to alter their business strategies in order to accommodate the growing 3D printing phenomenon to find logistical benefits including reduced inventory and streamlining of the supply chain (Cox 2014). Usually innovations with a greater degree of relative advantage are likely to have greater adoption rates (Carter and Belanger 2004).

Compatibility is the extent to which a potential adopter perceives an innovation to be consistent with existing norms in the organization (Wu et al. 2013). Previous research suggests increased perception of compatibility positively impacts adoption (Ettlie et al. 1984). From the perspective of logistics organizations compatibility might come into question when considering adoption, as applications of 3D printing have been focused more on manufacturing. However, with the recent adoption of 3D printing among logistics organizations (Manners-Bell and Lyon 2014) more are becoming aware of its potential for application in a logistics environment.
Complexity refers to the perception of an organization in terms of the difficulty of understanding and use of the innovation. Little so far is known about the logistics industry perception of the difficulty or use of 3D printing because minimal research exists. While 3D printing is becoming a less elusive concept with increased use among not only large manufacturing organizations, but consumers as well, in the area of logistics it is still in its infancy with very few existing examples. More research is needed, however, as complexity has been shown to significantly impact adoption (Agarwal and Prasad 1997).

Trialability is the degree to which an innovation can be experimented with on a limited basis (Rogers 2003). Over the past few years the democratization of 3D printing has substantially impacted the ability for 3D printing to be tested. Individuals can now purchase their own 3D printers to create a plethora of products designed through computer aided design (CAD) software (Kietzmann et al. 2014). While the 3D printers made for consumer purchases are considerably less advanced than industrial 3D printers, the basic concept of designing a product through CAD and printing it out helps improve trialability. However, given the advanced differences between industrial and consumer 3D printing, more research is needed to assess trialability from the logistics standpoint considering IDT research has shown trialability enhances adoption (Gupta and Jain 2014).

Observability is defined as the innovation’s visibility of results. Observability of 3D printing in manufacturing is slightly more advanced than in logistics. The benefits of rapid prototyping, reduction of scrap and inventory as well as decreased emissions have been realized by manufacturing (Morrow et al. 2007; Fogliatto et al. 2012; Huang et al. 2013; Beyer 2014). While organizations like UPS have continued to increase adoption of 3D printing, little is known about the potentially positive results from a logistics standpoint. Since IDT research stresses the importance of observability for adoption of innovation (Gupta and Jain 2014), more research is needed about the observability of 3D printing within the logistics industry.

METHOD

Context and Sample

Results from structured interviews will be presented in order to generate insight on adoption of 3D printing among logistics organizations. Interviews were conducted because 3D printing is representative of an underexplored area of research. Further, research questions addressed include how organizational innovation adoption category and perceived characteristics impact 3D printing adoption among logistics organizations. Interviews provide a better means of addressing “how” questions and thus provide a useful means of addressing this study’s research inquiries. Structured interviews provide a means of addressing hard to perceive quandaries that hinder supply chain management’s primary goal of value creation (Fawcett and Waller 2011; Fawcett et al. 2014).

Interviews were conducted with organizations that had adopted, were considering adoption, and those that had not adopted 3D printing. Interviewing individuals from all types of organizations helped address the potential rate of adoption and how certain perceived characteristics of 3D printing might impact adoption by organizations considering doing so and those that had no current interest. Information was collected about the organizations and industry in order to ensure the sample represented a diverse area of the logistics industry. This included the size of the company as well as individual demographics of each informant. All individuals selected in the sample were at the strategic decision making level and had a general idea of an organization’s actual adoption and potential adoption of innovations. Some individuals interviewed at lower levels of management were excluded from the results of this study.
Data Collection

Contact information was collected from a third party research organization. After removing data obtained from non-logistics industry professionals as well as individuals not at the strategic decision making level of a logistics organization, a total of twenty semi-structured interviews were collected (see Table 1).

Table 1: Company profiles

<table>
<thead>
<tr>
<th>Company Pseudonym</th>
<th>Industry (NAICS Code)</th>
<th>Size</th>
<th>Innovation Adoption Category</th>
<th>Adopted 3D Printing (time period)</th>
<th>Considering Adoption (time period)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td>Used households and office goods moving (484210)</td>
<td>Large (over 500 employees)</td>
<td>Late majority</td>
<td>No</td>
<td>Yes (1 year)</td>
</tr>
<tr>
<td>Bravo</td>
<td>Specialized freight (except used goods) trucking (4842)</td>
<td>Small (21-100 employees)</td>
<td>Innovators</td>
<td>Yes (1 year)</td>
<td>No</td>
</tr>
<tr>
<td>Charlie</td>
<td>Transportation and warehousing (49)</td>
<td>Large (over 500 employees)</td>
<td>Late majority</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Delta</td>
<td>Specialized freight (except used goods) trucking (4842)</td>
<td>Very small (20 employees or less)</td>
<td>Early majority</td>
<td>Yes (1 year)</td>
<td>No</td>
</tr>
<tr>
<td>Echo</td>
<td>Transportation and warehousing (49)</td>
<td>Large (over 500 employees)</td>
<td>Laggard</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Foxtrot</td>
<td>Transportation and warehousing (49)</td>
<td>Large (over 500 employees)</td>
<td>Late majority</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Golf</td>
<td>Transportation and warehousing (49)</td>
<td>Medium (101-500 employees)</td>
<td>Late majority</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Hotel</td>
<td>Courier (4921)</td>
<td>Very small (20 employees or less)</td>
<td>Early majority</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>India</td>
<td>Transportation and warehousing (49)</td>
<td>Small (21-100 employees)</td>
<td>Innovators</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Juliett</td>
<td>Specialized freight (except used goods) trucking (4842)</td>
<td>Large (Over 500 employees)</td>
<td>Early majority</td>
<td>Yes (1.5 years)</td>
<td>No</td>
</tr>
<tr>
<td>Kilo</td>
<td>Used household and office goods moving (484210)</td>
<td>Large (Over 500 employees)</td>
<td>Laggard</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Lima</td>
<td>Specialized freight (except used</td>
<td>Very small (20 employees or less)</td>
<td>Laggard</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>
RESULTS

Organizational Innovation Adoption Category

Within the “innovator/early adopter” category two out of the four organizations had already adopted 3D printing. This included Bravo and Quebec that had used 3D printing for the past one and two years, respectively. Bravo used 3D printing as a means for new product development in conjunction with its supply chain partners in the medical industry. Quebec, which serves as a consulting organization for the logistics industry, has had the most experience with 3D printing out of the twenty organizations interviewed. They primarily used 3D printing for “education” purposes directing other logistics organizations in this new emerging arena of technology.

Although Tango, another consulting service for the logistics industry, has not yet adopted 3D printing, it has current plans in progress to adopt it within one year to create “cost effective prototypes” and “models and samples” for clients. India was the only innovator that did not currently and had no plans for adopting 3D printing. The main reason for its reluctance to adopt was a lack of understanding regarding potential applications for logistics which is primarily service-oriented.

Within the “early majority” category, two out of the four organizations had adopted cloud computing. Delta, a small specialized freight organization, has been using 3D printing for one year. They decided to adopt for “curiosity” reasons and used the technology for developing models for its supply chain partners which specialize in light designs. Juliett, a larger specialized freight organization has been using 3D printing for 1.5 years and has a similar purpose of
developing models for its architecture clients. The two other early majority organizations, Hotel and Romeo, have not and do not plan to adopt 3D printing in the foreseeable future. Both of these organizations indicated there was a lack of need for 3D printing for couriers or transportation organizations.

Within the “late majority” category, one out of eight organizations has already adopted 3D printing, and one out of eight had intentions to adopt after two years. Sierra, a large transportation organization, has used 3D printing for one half a year for planning purposes in the expansion of public transportation using models to identify consequences of potential expansion. It has also helped in terms of getting more government funding focused on enhancing the adoption of advanced technologies. Papa, a consulting organization for the logistics industry, planned to adopt in the next two years for the sole purpose of keeping up with competition, but has not yet decided on potential applications. All of the “late-majority” organizations’ key identified reason for not adopting 3D printing and not having an intention to adopt in the foreseeable future focused on the lack of a known need for 3D printing in the logistics industry.

None of the “laggard” organizations indicated current adoption nor an intention to adopt 3D printing in the foreseeable future. One organization was not aware that 3D printing existed, and the other three suggested there was no need for 3D printing in their offices or the logistics industry.

After discussing innovation adoption categories the interview continued asking respondents what factors impacted their adoption of 3D printing or what factors about 3D printing would be needed for adoption. Several categories emerged as a result of asking these questions. This included innovation diffusion adoption categories. The relative advantage of 3D printing was discussed in terms of cost and speed of supply.

The first facet discussed during the interviews was cost. 3D printing was perceived to be both cost effective as well as expensive. Tango’s primary reason for adopting 3D printing was its cost effectiveness. Used primarily as a means of developing “models and samples” for its logistics industry clients, it was more cost effective to 3D print the models versus making them in house or using outside manufacturing organizations. Other organizations including Lima suggested a strong need for the cost of 3D printing to go “way down”. It appeared throughout the interviews that the view of democratization of 3D printing was substantially higher among the innovators and early adopters versus the late majority and laggards. While many of the laggards indicated a need for stronger monetary resources in order to adopt 3D printing, the innovator/early adopters discussed cost effectiveness as a relative advantage of 3D printing versus more traditional methods.

For these (models) we looked at them and we asked what it would cost today using 3D printing versus traditional (manufacturing) methods. Now it’s cheaper to make some products...several years from now every single product will be cheaper.

While cost relative advantage was a consistent predictor of 3D printing adoption among respondents, other dimensions of relative advantage emerged as well. These included perceived relative advantage in developing new models and products in conjunction with manufacturers and streamlining the delivery of parts and components.

Bravo specifically discussed that the reasoning behind adoption of 3D printing was the ability to work with its supply chain partners to enhance “product characteristics” through a joint effort using 3D printing technology for medical equipment. 3D printing helps medical transportation by working one-on-one with manufacturers to enhance “product characteristics” for easier transport.
Other organizations representing the late majority, Charlie, Foxtrot, and Oscar, did not foresee near term adoption. All acknowledged the “lack of an actual need” for 3D printing in transportation and logistics. In order for Charlie, Foxtrot and Oscar to adopt 3D printing, general knowledge is needed as to how the use of 3D printing would “speed up supply chain delivery of parts.”

**P₁.** *Perceived relative advantage of 3D printing will enhance adoption among innovator/early adopter, early majority, late majority and laggard organizations.*

The second facet of 3D printing which the respondents discussed was its compatibility with current organizational resources, strategic vision and technology infrastructure. Many of the respondents expressed the importance of 3D printing “fitting in” with their organizations’ current resources. For example, the November respondent discussed how 3D printing would be viable if the organization had a “plant, utilities, equipment and employees” to help support its use. Without this, and without having access to these resources, the November respondent had no intention of adoption. Further, the Papa respondent suggested that the decision to adopt would be contingent on the ability for 3D printing to become part of its organizational culture through progressive evolution in “ease of learning”. Similar to IDT’s complexity, instead of Papa’s employees needing to be trained sufficiently, 3D printing would need to evolve into a technology in the next two years that was easy enough to be used by the current employee base, or in other words requiring compatibility between the “ease” of 3D printing and current employees.

The majority of respondents in the laggard and late majority category who had no intention of 3D printing adoption indicated adoption would not be considered due to its lack of compatibility with current strategic initiatives. Organizations like Echo, India and Mike view 3D printing as beneficial strictly for manufacturing, but not for service and logistics organizations. This lack of compatibility with a logistics organization was the primary reason addressed for not adopting 3D printing in the majority of the interviews.

**P₂.** *Perceived compatibility of 3D printing will enhance adoption among innovator/early adopter, early majority, late majority and laggard organizations.*

The third facet of 3D printing discussed was complexity which refers to the difficulty of understanding and using 3D printing. Unlike the other facets of 3D printing like relative advantage and compatibility there seemed to be a divide between innovators/early adopters and early majority with late majority and laggards on the importance of complexity to adoption. Innovators/early adopters and early majority like Quebec and Delta tended to adopt and have an intention to adopt innovations like 3D printing regardless of their perceptions of complexity. Quebec adopted 3D printing for the sole purpose of reducing complexity.

*We adopted 3D printing as a means of educating ourselves and our clients.*

However, late majority and laggards like Alpha and Kilo both discussed the pertinence of understanding the functionality and application of 3D printing before considering adoption. That is, while innovator/ early adopter and early majority may use the innovation as a means of education, late majority and laggards preferred to reduce the complexity associated with the innovation before adoption. Specifically, complexity in terms of software tools associated with CAD was mentioned as well as the general applicability of 3D printing for logistics.

While the interviews pointed out that innovator/early adopter and early majority like Quebec and Delta adopted regardless of the complexity perception, it is also important to note...
that other early majority organizations like Juliett used 3D printing for “specific test markets”.
There are two different arguments which can be made: (1) test markets are considered a form
of adoption, and (2) test markets are not considered a form of adoption and are just a way to
reduce complexity. While both arguments are valid, this study’s findings found late majority and
laggard organizations would not adopt 3D printing on any scale unless complexity (among other
dimensions) was reduced. Given this discrepancy, further analysis on the following propositions
is needed.

P₃. Perceived complexity of 3D printing will decrease adoption among late majority and laggard
organizations.

P₃a. Perceived complexity of 3D printing will enhance adoption among innovators/early adopter
and early majority organizations.

The fourth facet of 3D printing discussed was trialability which refers to the degree to
which an innovation like 3D printing can be experimented with on a limited basis. Innovator/early
adopter and early majority organizations like Quebec and Delta adopted noting that 3D printing
was an available resource at the time of adoption. This included both at the consumer level
(affordable) 3D printers as well as industrial level printers.

Similarly, the late majority and laggard organizations like Papa and November both
required a certain level of trialability in order to adopt 3D printing. The Papa respondent
indicated that while the organization planned to adopt 3D printing in the next two years, it was
necessary to have “access” for experimentation purposes before investing in the technology.
November also indicated a need for testing a 3D printer before actual investment.

P₄. Perceived trialability of 3D printing will enhance adoption among innovator/early adopter,
early majority, late majority and laggard organizations.

Observability was the fifth facet of 3D printing discussed which refers to the visibility of
3D printing’s positive results. The importance of observability for 3D printing adoption was
standardized among the innovator/early adopter, early majority, late majority and laggard
respondents. The majority of the respondents indicated the importance of management
awareness of the helpfulness and flexibility of 3D printing to the logistics area before adoption or
even testing of the 3D printer.

The respondents from early majority organizations like Juliett suggested that
management was aware and needed to see how 3D printing could be used to successfully
develop models for clients before initial adoption. Moreover, Delta also declared it had some
foresight through previous experience on the positive implications of 3D printing before adoption.
Other late majority and laggards like Golf and Lima implied that top management had limited
evidence regarding the use and general criticalness of 3D printing in their organizations.

P₅. Perceived observability of 3D printing will enhance adoption among innovator/early adopter,
early majority, late majority and laggard organizations.

Aside from the five IDT perceived characteristics of relative advantage, compatibility,
complexity, trialability and observability, two other categories emerged as a result of the
interviews: image and intellectual property (IP) protection. Image is the degree to which the use
of an innovation enhances an organization’s status (Moore and Benbasat 1991). The
respondents from organizations which had adopted 3D printing indicated their organization’s
image to state government, competitors and consumers were all vital in considering adoption.
For example, Sierra expressed one of the main reasons for adoption was to make their organization "more visible to the state in order to get more funding". New government funding programs in the United States, United Kingdom, China and Japan have started programs on not only funding, but also educating the public on 3D printing (Grunewald 2014; 3ders 2014). Both the organizations which adopted and were considering adoption of 3D printing among the innovator/early adopter, early majority and late majority categories indicated that 3D printing not only enhanced their reputations for further state funding, but also enhanced their reputations among competitors. For example, Papa’s respondent expressed the primary reason for planning to adopt in the next two years was simply a need to exert itself as a consulting organization that was “keeping up with current technology trends”. Lastly, the majority of organizations that were not planning to adopt 3D printing indicated they had not seen enough evidence supporting a need for the use of 3D printing from their direct consumers or clients. For example, the respondent from Mike indicated the company would need to have a direct client request indicating there was a desire for the organization to adopt. At the time of the interview the respondent from Mike had no client requests and suggested that 3D printing would not immediately make enough of an impression on the client.

The archival analysis had a large portion of interviews conducted regarding the importance of IP protection to organizations wishing to adopt 3D printing. Organizations like Bravo that use 3D printing in conjunction with other organizations face the danger of IP infringement, especially considering that data and CAD models need to be shared through common platforms. The archival analysis entailed many interviews focusing on the impact of IP protection on adoption. One 3D printing expert suggested:

> The problem (IP infringement) is very real. And I think at this point we need to make sure that we move forward in a way that we protect (ourselves). The music and video industries saw a lot of destruction with the advent of online media. And so the legal community struggled for a little while and eventually came up with DMCA Digital millennium copyright act, to protect those things. We’re seeing a few things in the 3D printing industry. (Council on Foreign Relations 2013)

While Bravo can privatize the information they share with their partner organizations, limited IP protection exists for 3D printed modelling or data. The archival data analysis suggested that organizational stress about IP infringement was one of the main inhibitors of 3D printing adoption.

\[ P_6. \] Perceived image improvement from 3D printing will enhance adoption among innovator/early adopter, early majority, late majority and laggard organizations.

\[ P_7. \] IP protection will enhance adoption among innovator/early adopter, early majority, late majority and laggard organizations.

CONCLUSION

This paper attempts to help establish an understanding of 3D printing adoption among logistics organizations. Results provide a description of the impact organizational innovation adoption category and perceived characteristics of 3D printing have on 3D printing adoption in the logistics industry. Specifically, through the use of IDT, interviews with industry professionals and an extensive archival data analysis reveals organizational innovation adoption category and perceived characteristics of 3D printing (relative advantage, compatibility, complexity, trialability,
observability, image, and IP protection) all have an impact on 3D printing adoption intention among logistics organizations.
REFERENCES

References available upon request.