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The Future Emergence of 3D Printing Through the Lens of a Business Model

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Abstract.

Unlike other technologies, 3D printing has a unique development path. Currently, the limitations for the technology have not been set allowing for a diversity of applications and innovations to the point where some consider it the fourth industrial revolution. With continuous development of 3D printing and a growing industry, the future emergence of 3D printing in the UK comes into question. This dissertation aims to answer the question of how do 3D printing actors in the UK perceive the future emergence of the technology through the lens of a business model. To answer this question, a qualitative study utilising both observation and interview data is undertaken. The data is analysed thematically resulting in an overarching theme of uncertainty around business models and the technical adoption of 3D printing. This ambiguity creates conflicting views and gaps in the current industry highlighting how 3D printing is still in its embryonic stage. The findings bring about a new perspective to the business model canon along with insights into this emerging industry in the UK. Lastly, the research raises new areas for future research in business models, emerging technologies, and 3D printing.

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1. Introduction.

With 3D printing's near end-less applications and ability to provide fine-tuned, bespoke manufacturing, this new means of production has been considered by some as the fourth industrial revolution¹. It certainly feels like it, with the numerous application of 3D printing highlighted in the media. There are examples of 3D printing used for printing organs and prosthetics, to replacement parts and prototypes in the automotive and aerospace industries, to art and toys with jewellery and 3D printed models of people (Chowdry, 2013).

Despite the previous hype in the media, 3D printing is thirty to forty years old. However, unlike many other technologies, it has experienced a different development path with its limitations not yet established². In fact, key patents for 3D printing from the 1970s and 1980s have only recently expired (Bechtold, 2016). This, paired with increasing investment- the global 3D printing investment is set to increase to almost \$27 billion by 2019 (Holt, 2017)- and innovation surrounding 3D printing is causing the industry to explode with a growing ecosystem. Though hype surrounding 3D printing has moderately calmed, it appears that the technology is certainly making a mark and likely to become increasingly prominent.

This then brings up interest in the technology's future applications, trends, and overall emergence. With the expanding uses of 3D printing and the increasing investment in the technology, this begs the question of what the future of 3D printing is. In particular, how do 3D printing industry actors in the UK perceive the future emergence of 3D printing? Given that commercial success of a technology is as important as developmental success, examining business models and how business model change is also of interest. Thus, the research question evolves into how do 3D printing industry actors in the UK perceive the future emergence of 3D printing through the lens of a business model?

The aim of researching and answering the above question is to better understand how industry actors perceive and understand business models, and how they are adapting and preparing for changes in the industry. The findings and insights that emerge from the research would add to the current literature on business models, 3D printing, and emerging technologies in general. Not

¹ Paraphrased from Speaker D.

² Paraphrased from Participant C.

only that, but it would highlight what issues are the most pressing or influential for industry participants, providing a guide for future research and policy development.

The initial hypothesis is that informants would have varying views and interpretations of business models leading to various means of business model innovation. As the technology is still developing and growing, there are likely to be varied and even possibly conflicting views on future 3D printing trends, but particularly in determining value ownership for mass customised designs.

This hypothesis is investigated by firstly providing an overview and examination of relevant literature. The areas evaluated are research and theory concerning business models, business model innovation, technology and business model innovation, and the value implications of mass customisation. Next, the research design and methods are explained before presenting the findings. Afterwards, analysis of the findings are discussed with the implications.

2. Literature Review.

Based on the current literature, business models and 3D printing's future remain undefined with multiples perspectives chiming in. This is investigated by first evaluating the business model and business model innovation canon. Next, the relationship between technology and business model innovation are analysed before providing a brief introduction to the debate on mass customisation and value.

2.1 Business Models.

2.1.1 What is the purpose of a business model?

Business models encompass frameworks, practices, and/or strategies of how a company successfully operates and profits. The general overview of the literature reveals different definitions of what a business model is and what it is composed of. Despite these differences, the overarching theme is that a business model provides an overview of the strategy of how the business captures and delivers that value. It essentially defines how the business operates, what value it offers to its customers, and how it captures that value.

The concept of the business model formally emerged in Amit and Zott's (2001) *Value Creation in E-Business* article where they introduced it as a new means of analysing emerging internet-based companies. They described the business model as the design of the organisation's transactions, structure, and governance to create and extract value from business opportunities (Amit and Zott, 2001). The overall purpose of this was a means of understanding how new internet and e-commerce businesses were functioning both similarly and differently from established brick-and-mortar companies. The model suggested by Amit and Zott has led to various interpretations, along with compilations of different types of business models and how new means of value are created.

For instance, business models have become a means of structuring a business' strategy. Hamel (2000) argues that business models are methods of value creation and capture with new models developed in the value network, which include suppliers, partners, distribution channels, and more. Afuah (2004) wrote how the business model is a set of components that correspond to the determinants of a firm's profitability. IBM's 2006 report took this further to identify three types of business models that focus on different means of how a business achieves profitability: industry models that focus on supply chains, revenue models that focus on how companies generate value, and enterprise models that focus on the structure of the enterprise in new or existing value chains.

All in all, these approaches take on the view of the business models as a strategies that determine the firm's performance.

On the other hand, other researchers take a more structural approach rather than performance view. Osterwalder et al. (2005: 7) differentiate a business model as the firm's logic for creating and commercialising value and maps out how pieces of the business fit together, whereas a business process is how a business case is implemented, and a strategy takes into account the performance of competitors. From this Osterwalder and Pigneur (2010) developed the business model canvas which lays out nine building blocks of a business model. Similarly, Zott et al., (2011) refined their introduction of the business model to be a unity that is structured in accordance to three primary elements: content of activities that are to be performed, structure of how and what sequence activities are linked, and governance of who performs each activity.

There has also been an emergence of research taking a more social constructivist approach. In this view, business models are variable and change unintentionally compared to the more structural and intentional perspective to business model development, like Amit and Zott (2001) and Osterwalder et al., (2005). Taking a similar stance to Hamel that networks influence the value creation and capture model, Doganova and Eyquem-Renault (2009) interestingly suggest the business model to be a market device and a narrative that evolves through social interactions. A successful business model balances the tension between framing and structuring the business with the necessary fluidity for flexibility and adaptability (Doganova and Eyquem-Renault, 2009). In essence, the business model allows for founders to calculate risks while also being a narrative of the business that is flexible enough to adapt to partners and audiences. Business models are calculated social constructions of business practices that adapt to their audience.

All in all, this reveals that there is no single definition and construction of what a business model is. This section highlights how there is no universal conception of a business model and business model definitions differ based on perspective and use, both for research and business. However, despite this lack of agreement, there is the overarching theme that a business model serves as a means to explain how a company creates and captures values. Perhaps the increased prevalence of the business model may lie in it becoming a popular and helpful tool for both managers and scholars to describe businesses and their behaviour (Baden-Fuller and Morgan, 2010). Thus, based on this initial review, I would hypothesise that businesses have different conceptions of what a business model does, but would essentially explain how the business makes money.

2.1.2 Why are Business Models Important?

In this section, the importance and relevance of business models are investigated. Perhaps the importance and interest placed on business models lies in how understanding them allows for understanding how value is created and captured, as well as the business practices. This in turns allows for opportunities to create models of how businesses operate and function for better study and identification of innovation opportunities.

Relating back to Amit and Zott's (2001: 503) value drivers in e-commerce businesses- efficiency, complementarities, lock-in, and novelty-, these interrelated drivers provide value creation potential. As the varying presence of each driver can enhance effectiveness in another driver, understanding how these value drivers are organised and executed is important (Amit and Zott, 2001: 503). Analysing this provides insights into wealth creation and sources of value. From there, scholars, managers and entrepreneurs can examine the different combinations and whether or not they have been successful (Baden-Fuller and Morgan, 2010: 67). Knowing and having models, frameworks, or tools to explain how the company makes money aims to demonstrate the feasibility and worth of the enterprise both internally and externally (Doganova and Eyquem-Renault, 2009: 1568).

What is perhaps more interesting and important is that understanding business models creates opportunities for innovation. Firstly, business models create opportunities by allowing companies to commercialise innovative ideas and technologies (Zott et al., 2011: 1032). Thus, business models provide an outline and a means of getting innovations to market.

When viewing business models from a strategy and performance perspective, business models are a source of competitive advantage (Mitchell and Coles, 2003). Given that a business model focuses on value, if one is able to alter a company's model to establish better means of managing and executing their value drivers, the company is likely to have a great competitive advantage. For instance, Netflix's Cinematch software creates a lock-in for its customers by suggesting personalised and relevant content to its users along with collecting data to create successful Original series that have greater critical acclaim along with viewership preference (Carson, 2016). Therefore, the business model not only allows for innovation to come to market but also provides opportunities for innovation in commercialisation.

To summarise, the importance of business models proves useful for business and research. Business models provide a means of understanding and comparing how companies create and

capture value. By understanding this, business models then provide opportunities for innovation by bringing innovation to market and innovating how to operate and navigate the market. This leads into how and why companies should innovate their business models.

2.2 Business Model Innovation.

2.2.1 What does business model innovation involve?

Like business model creation, business model innovation has multiple definitions and conceptions of how it can occur. Generally though, business model innovation entails changes in a business model. These changes tend to involve alterations in value generation, capture, and delivery of the business.

Taking from IBM's 2006 report, Giesen et al., (2007), presents a structural and strategy perspective by elaborating how companies can innovate their models in accordance to industry, revenue, and enterprise models. Firstly with the industry model, business model innovation focuses on innovation in the industry value chain by leveraging white spaces in the competitive environment and unique assets (Giesen et al., 2007: 27). This can be seen, for instance, in horizontal expansion like Virgin with its activity in air travel, banking, and entertainment. Another area this can be seen is through execution of blue ocean strategy whereby businesses create new value innovations, market spaces and industries; for example, what Cirque du Soleil did outside the circus industry (Kim and Mauborgne, 2004). Though blue ocean strategy may not be considered a business model innovation by some as it considers competitors, it does demonstrate how business model innovation can occur through a means of creating new markets that create new industries and value propositions.

As for revenue models, innovation in this area pertains to how companies generate revenue by reconfiguring offerings and/or introducing new pricing models (Giesen et al., 2007: 28). An example of revenue model innovation is the Netflix case of shifting the DVD rental industry from late-fees to a subscription model (Castillo, 2013). In this area of business model innovation, the focus can shift towards a means of reducing the company's costs while simultaneously offering a new value proposition and capture means. As in the Netflix example, the subscription model provided an easier means for customers while also offering the company a consistent source of revenue.

Lastly for the enterprise model, innovation focuses on the structure of the enterprise and its role in new and existing value chains (Giesen et al., 2007: 28). One type of enterprise model innovation

is the new emergence of keiretsu systems- arrangements whereby buyers form close associations with suppliers (Aoki and Lennerfors, 2013). For instance, Toyota has initiated a cost-focused approach of not solely relying on their suppliers but also examining the global market while simultaneously upholding traditional practices of commitment and support with suppliers (Aoki and Lennerfors, 2013). In this case, business model innovation focuses on changes in business practices that allow the company to maintain a competitive edge. Another type of enterprise model innovation would be around moving towards specialisation. In this case, the company moves from general services or products to more specific and specialised offerings which offer greater potential for value proposition, industry authority, and higher customer conversion (Alton, 2016).

Moreover, these business model innovation types focus on strategic changes in a company as well as new strategies, structures, and models in an industry. These changes focus on improving a firm's competitive standing and effectiveness measured by their competitive edge.

Given that business models can also be considered social constructions and practices, business model innovation can also include changes driven by social interactions and routines. In Doganova and Eyquem-Renault's (2009) case study, analysis of a French university spin-off found that the business model can be fluid and form multiple versions as the business model circulates amongst stakeholders and business allies. This circulation allows for the aforementioned influencers to shape and gradually forge a new business model. This social means of adaption demonstrates how business model innovation can be based on the influence of stakeholders and allies such as investors requiring certain changes as well as providing suggestions (Doganova and Eyquem-Renault, 2009: 1566). In this social constructivist perspective, business model innovation can occur through interactions with a business' network as the network players' influence can lead to changes. This is seen in the case study where the start-up reoriented its market focus and company structure based on their stakeholders influence (Doganova and Eyquem-Renault, 2009: 1567).

Not only can social interaction present opportunities for business model innovation but even business routines provide opportunities for business model innovation. A recent argument presented by Nair et al. (2017) views business models from a routine dynamics perspective, where business models are constructed as practices rather than theoretical constructions. In routine dynamics, the concept focuses on how routines are practices with internal dynamics that provide stability and change in an organization (Feldman and Pentland, 2003). In an earlier work,

Cavalante et al. (2011) present a similar process-based conception of business models which considers the role individual agency. All of which demonstrates how processes and practices not only suggest one conception of a business model but also provide opportunities for business model innovation.

Moreover, taking a constructivist view reveals that business models can also be considered social and process-driven which in turn presents opportunities and various means of instituting change and innovation.

All in all, like defining and constructing business models, business model innovations also coincide under a single definition. Similarly, innovation of business models can occur through various means, from strategic opportunistic changes to changes based on process and interactions. Despite these differences in perceptives and definition, the underlying theme is that business model innovation focuses on changes in the company's business model. Similar to the initial hypothesis of business models, I hypothesise that companies would also take different approaches to business model innovation.

2.2.2 Why should businesses innovate their business model?

Changing a business' model can be a daunting task. Despite this, business model innovation is an important aspect for companies. It provides a means of transformation and sustainability. In doing so, it creates opportunities for a firm to better create and capture value.

To begin with, business model innovation allows a business to not only change but transform itself and its networks. Zott et al. (2011: 1033) found that business model innovation provides a vehicle for corporate transformation and renewal which may require a specific leadership agenda. How a company designs and structures itself and how it creates and captures value is an important source of innovation, which also affects the firm's suppliers, partners, and customers (Amit and Zott, 2001). For instance, Netflix as a company evolved from movie rentals to a production company with their original content, thus expanding its value proposition along with its network as it moves towards creating its own TV and film content (Mui, 2011). Not only does business model innovation provide opportunities for network and company transformation, but it also creates changes in existing markets (Rayna and Striukova, 2015: 222).

The main reason that a business should innovate its model is to ensure sustainability of the company. Business models are a source of competitive advantage and innovating them can help create a sustainable business (Mitchell and Coles, 2003). Firstly, the main evidence of sustainability through business model innovation is that fewer companies tend to change their business model, but those that do tend to see greater growth in the long-term than companies that simply change their product offering (Geisen et al., 2007: 27). For instance, business model innovation tends to lead to high returns of equity particularly for businesses with more experience of working in alliance with other businesses (Bouncken and Fredrich, 2016). To ensure a sustainable and successful evolutionary strategy, a company requires internal diversity and change that is superior to the environment (Osterwalder et al., 2005: 16). Furthermore, innovating one business model creates a new means of obtaining a competitive advantage.

2.2.3 What are the barriers and challenges to business model innovation?

Although it provides numerous positive advantages for companies, business model innovation, given the huge structural, strategic, and ideological changes involved, has multiple challenges and barriers to its success.

Structurally and strategically, business model innovation should create a shift in the business without deviating too far from the core business. If taking the structuralist approach to business model innovation, companies would benefit from being aware of the trends in model changes and how changes affect networks. For instance, Geisen et al. (2007: 31) found that an increasing trend of extended enterprise model innovation led to an increased number of external partnerships but also consequently made collaboration harder as these companies became entrenched in their new networks. The strategies for the business model innovation ought to be aligned with the company's brand operations, core strengths, and other assets to ensure greater likelihood of success (Geisen et al, 2007: 31).

In terms of ideological challenges, business model innovation requires a reorientation of the mind-set and views of the actors within and allies of the business. A first challenge is that change requires overcoming entrenched perspectives, biases, and occasionally organisational culture for the firm to be open to innovation and even repeated innovation of its business model (Gobble, 2014). Company culture, for instance, has one of the greatest powers to shape a culture of innovation and lead to a sustained competitive advantage, but due to its intangible nature, it is very difficult to handle (Rao and Weintraub, 2013: 29). The bigger the organisation the more resistant it is to change, yet one can start by leveraging small successes into broader

transformation (Rao and Weintraub, 2013: 36). This demonstrates how company culture, as an example, can support innovation capabilities of a firm while also being a great hurdle to innovation.

2.3 Technology and Business Model Innovation.

As mentioned in the first section, a business model is a source of innovation through creating new ways of value capture and creation but also by bringing innovative products and services to market. Conversely, new technology is also capable of bringing about new business models, such as the Internet with the development of e-commerce companies. However, success of a new technology and the businesses that surround it are both reliant on a successful business model. With a focus on 3D printing, this section aims to demonstrate how technology and business model innovation relate, but first provides background into the 3D printing industry.

2.3.1 3D Printing Technology.

To provide a brief overview, 3D printing technology is decades old but has been rapidly improving both in terms of quality, price, and ease of use as well as the diversity of complementary services and companies. Additionally, how 3D printing technology is used is also changing. Though still far from mass market adoption, 3D printing could potentially evolve from a hyped tech into everyday household product like a printer.

2.3.1a 3D Printing Background.

3D printing, also known as additive manufacturing, is a production technique whereby a 3D object is built by adding layer after layer of a particular material (Rayna and Striukova, 2015: 215). The origins stem from manufacturing research in the 1970s and 1980s when many of the important patents for 3D printing technology were created (Bechtold, 2016). From the 2000s, many of the key patents for 3D printing technology in the 1970s and 1980s expired leading to increased use of 3D printing along with reductions in the cost of 3D printers and materials (Rayna and Striukova, 2015: 215). Quality also increased which led to 3D printing becoming a viable means of creating end-consumer products through direct manufacturing (Mendis et al., 2015: 2). The technology works as follows: an object is scanned with a 3D scanner to create a digital copy or an object is completely designed digitally through the use of Computer Aided Design (CAD) software, before the file is sliced into instruction for the 3D printer (Bechtold, 2016: 519). An important point to highlight is that despite the focus on the 3D printers and materials the key factor in 3D printing

lies in the software and the design file. A 3D printer without proper and adequate software and a CAD file is like an iPod without music (Mendis et al., 2015: 3).

2.3.1b 3D Printing Trends.

With the development of 3D printing technology paired with its increased availability, there are interesting trends that have emerged in the industry and out with. For instance, how 3D printing had been used has expanded with different applications. Rayna and Striukova (2015) identified four main applications of 3D printing: 1) rapid prototyping, 2) rapid tooling, 3) direct manufacturing, and 4) home fabrication. Rather than each generation of usage replacing the previous, it extends the life of the previous and provides a new application of 3D printing for that generation (Rayna and Striukova, 2015: 217).

Another interesting trend is that with the emergence of home fabrication from the reduction of cost for 3D printing, it has created a new innovation ecosystem for 3D printing. Though initially based in research-intensive manufacturing, 3D printing decentralisation into consumer markets and homes has led to development of new actors and businesses. This can be seen with the emergence of open source software programs and communities for 3D printing, design file sharing and selling platforms, new software programs, 3D printing service providers, and more (Bechtold, 2016: 524). The main factors enabling this increase in actors lies with the increased affordability of 3D printers and software paired with increased accessibility of software and hardware expertise (Ferdinand et al., 2016: 4). Despite the emergence of such actors, as a whole the 3D printing community and ecosystem is not yet a mass phenomenon (Bechtold, 2016; Mendis et al., 2015: 5).

2.3.2 Technology and Business Model Innovation.

Now, the importance of business model innovation and technology is that a technology is only as successful as the business model that works for it (Rayna and Striukova, 2016). If a business is not able to commercialise and obtain the value of the technology, it is then unlikely to go to market or be in the market for very long. Because having the correct business model for the technology is important, this adaption to the new technology creates opportunities for business model innovation as well as challenging traditional models (Bechtold, 2016: 521). As for 3D printing, such changes are coming into initial view.

A main theme in the literatures in regards to business model innovation revolves around how 3D printing is changing production networks by decentralising and democratising manufacturing. With the 3D innovation ecosystem, design and production is democratised by allowing customers to create their own products according to their preferences and needs at home or through a 3D printing service (van den Berg, 2016: 1-2). The 3D printing community's expansion (despite still remaining niche) has led to more distributed control and more laterally oriented power structures (Troxler, 2016: 110). This corresponds to the home fabrication application and challenges traditional mass production techniques while simultaneously empowering the end-user and creating new complementary businesses. However, a major challenge remains that despite increased affordability of 3D printers and supplies, 3D printing remains more expensive than traditional mass production methods (van den Berg, 2016: 1-3). Still though, as 3D printing reduces the need for transportation and can bring production closer to the customer (Ferdinand et al., 2016: 206), it creates a more decentralised production system.

In addition to manufacturing changes, 3D printing raises intellectual property (IP) scenarios and challenges which may affect businesses. The sheer digital nature 3D printing technology allows the creation information of a product to be completely separated from its production (Bechtold, 2016: 522). Given that a CAD file not only holds information regarding the design but how the product is to be produced creates a new separation in manufacturing. Also, design files can be more easily shared which has led to 3D printing online platforms where designs can be bought and shared, while concurrently, specialising designers into those who focus on 3D printing designs (Mendis et al., 2015:5). However, it also creates new challenges in how companies are to protect current intellectual property rights as design files become digital and products can be reverse engineered with 3D scanning. Despite these intellectual property challenges from the increased digital nature of the industry, 3D printing also creates new opportunities and challenges for open innovation as seen in co-creation processes. Redlickh and Mortiz (2016: 57) noticed how there was a shift towards more open creation approaches which then dissolve traditional boundaries of design and stakeholders become integrated in the value of the co-creation process. In co-creation, where the value lies and who owns it becomes more muddled and this can especially be seen in mass customisation, which will be evaluated in the next section. With 3D printing and intellectual property, the value is becoming increasingly digital as files and software become the source of value. This in turns leads to new opportunities and new business models to exploit such opportunities but also new risks for businesses protecting their value. In addition,

the digitalisation of value and shift towards co-creation creates challenges in identifying who owns the value in 3D printing.

A third theme highlights the need to be cautious in regards to the hype surrounding 3D printing. Despite these exciting new means of revolutionising industries, markets and business models, if 3D printing technology is not paired with the necessary business models it can create detrimental consequences to the ecosystem and technology. Based on the hype cycle, Coopersmith (2016: 137) found that every new “revolutionary” technology leads to an increase in companies working with or related to that technology, creating a “froth.” If the “froth” bursts, it may have huge negative consequence on the image of the technology and investment landscape. The initial signs of this may be coming with 3D printing receiving increased hype in 2007 that peaked in 2011 with unproven viability, particularly with regards to mass market adoption; however, its saving grace may be in distinguishing 3D printing either as ‘consumer 3D printing’ or as ‘enterprise 3D printing’ (Ferdinand et al., 2016: 2). This further iterates how an adequate business model is needed for a new technology along with the necessary of business model innovations for 3D printing based businesses.

All in all, the key takeaway is that new, innovative technologies need adequate business models to be successful. Not only that, but new, emerging technologies provide opportunities for business model innovation as they present new opportunities and challenges. In the case of 3D printing, as the technology improves and becomes cheaper, it creates opportunities for new applications, complementary businesses, and a growing ecosystem. This is establishing new business models as well as new factors to consider in business model creation and innovation.

2.4 Mass Customisation and Value.

In the previous section, co-creation was briefly discussed as a new means of design as well as an intellectual property challenge by muddling where and to whom the value of a design lies. This can be especially seen in mass customisation as the line between end-user/customer and producer/designer can become blurred the more customers become involved in the design process. This is particularly interesting, as firstly, it creates possible challenges for current intellectual property protection laws and secondly, as there is limited literature discussing these issues in 3D printing. In this section, mass customisation and value are reviewed to understand who the value of a 3D customised product lies with.

2.4.1 What is mass customisation?

Initially, background and explanation is provided for what mass customisation entails. Firstly, mass customisation is a means of providing unique, customised products on a mass scale. In mass customisation, businesses use bespoke tailoring to forge unique, individual products that all have the same core component or base design, like in mass production (The Economist, 2009). A goal in mass customisation is to produce in accordance to an increasing variety of customer requirements without increasing cost in production (Tseng et al., 1996).

Now, how companies obtain that goal and undertake mass customisation revolves around different means. Gilbert and Pine II (1996) identified four faces of mass customisation: collaborative, where customizers work with clients to articulate their needs and make the customised product; adaptive, where customizers offer a product with a standard base that customers can change to alter its use; cosmetic, where a customizer offers a standard product which customers can change the cosmetic appearance of; and finally, transparent, where customizers offer unique customisations without their customers knowing so. Gilbert and Pine II's approach highlight how mass customisation is a spectrum where on one end the customer has little control in customisation as in the cosmetic approach and on the other end where the customer is co-creating with the customizers like in the collaborative approach.

However, for companies to be able to provide these mass customised services, they have to take on cost and complexity risks. Historically, mass customisation took upon an engineering approach with the aim of addressing an increasing variety of customers' requirements without increasing cost which has not been successfully developed (Tseng et al., 1996). Additionally, firms have taken on mass customisation, which requires readily available information technology and flexible work processes, without fully considering the type of customisation their customers need leading to unnecessary costs and complexity (Gilbert and Pine II, 1996). Now given that 3D printing can produce small quantities of goods at relatively low costs and is reaching quality levels suitable for direct manufacturing and medical needs (Berman, 2012), 3D printing provides an alternative means of producing mass customised items more efficiently.

2.4.2 Intellectual Property Rights and Mass Customisation Debate.

With mass customisation altering the distinctions between designer/producer and customers, it has also brought into question who owns the value of the design and the product. There are two perspectives on this issue that can be taken into consideration. There is the legal side which

focuses on ownership of the intellectual property rights of the design, and there is the business perspective of who reaps the financial benefits. Literature regarding mass customisation in 3D printing is highly limited, perhaps due to the newness of the technology, but insights from other areas and industries that use mass customisation can be taken to provide an initial view. This section aims to provide a brief introduction to the debate regarding mass customisation and value by examining it from the legal and business perspective.

From a legal perspective, mass customisation is changing past conceptions of intellectual property rights (IPR) ownership by generating new opportunities and challenges. Menard (2015) notes that historically IPR policy has been driven by rights holders but with mass digitisation and sharing of files, as in mass customisation, tension is created between upholding private property and correcting social inequality. In his research, he finds that legislative outcomes are split between modest protection for IPR holders and gains in open access rights (Menard, 2015). This highlights the contentious nature in digitalisation and co-creation that mass customisation can entail in the IPR policy sphere as it challenges traditional protection conceptions. Currently though, the stance is that IP laws in the UK are sufficient to meet the current stage and prevalence of 3D printing and mass customisation, but the challenge lies in adequately gauging when to implement new laws that protect IPR without compromising on creativity (Mendis et al., 2015).

As specialisation is a means of innovating one's business model to offer greater value propositions, it suggests that businesses that offer specialisation or customisation of products on a mass scale would generate greater value proposition for its customers thereby suggesting that the value remains with the designer/producer rather than the customer. In fact, customers were found to be more willing to pay significantly higher prices for self-designed products which was found to be fuelled by feelings of accomplishment, satisfaction of the outcome of the process and perceived contribution to self-design (Franke et al., 2010). Looking more specifically, Utrich (2009: 10) found that customer find utility in customisation by allowing it to solve their own problems. However, for success in customisation and achievement of utility, the object and process of customising the object needs to be perceived as successful meeting requirements, otherwise the customisation process is unlikely to satisfy the need for competence and efficacy (Pierce et al., 2003). This demonstrates that in customisation customers are willing to pay for and pay more for customisation as long as the process creates utility and a successful product and process. This suggests that designers and producers are owners of the IPR value as mass customisation is viewed as an enabler of solving problems and satisfying needs of customers, and hence a value proposition for the business.

To sum up, the current debate in mass customisation has two perspectives, the legal and the business, in the literature. The legal sphere is being challenged with 3D printing and mass customisation with a tension between protecting rights holders and accounting for social inequality. On the business side, the perception is that value lays with the business or designer as they empower the customers. However, this only provides a limited scope due to the limited available research.

2.5 Conclusion.

The literature is filled with ambiguities in addressing business models and 3D printing. According to the review, there is no agreed conception of what a business model exactly is by academics and researchers. However, there is consensus that the focus of business models centralises on conveying or understanding the company's value capture and creation capabilities. This along with business model serving as source of innovation highlight the importance and relevancy business models play for research and practice. Given that business models are a source of innovation, innovating one's business model creates opportunities for a competitive edge and sustainability. Like the business model literature, there are multiple means of innovating one's model. Though business model innovation creates new opportunities, there are hurdles to successful implementation. Similarly, a new technology creates innovation through the new technical applications and business model innovations. In the case of 3D printing, the changes that are emerging from the literature are based in democratised production and new IP challenges and opportunities. However, one needs to be cautious. The hype around 3D printing creates new businesses and markets but if unsuccessful in the markets then it can be detrimental. One hyped application of 3D printing is mass customisation. As 3D printing becomes more digital and allows for customisation, mass customisation and IPR ownership come under question. Like much of the other sections, it varies according to one's perspective. Thus, the initial literature suggests ambiguity and uncertainty surrounding business models and the future emergence of 3D printing.

3. Research Methodology.

The overall aim of this study is to understand what the future emergence of 3D printing could be through the lens of a business model. This is to understand how 3D printing small and medium sized enterprises in the UK have changed and adjusted to trends- particularly mass customisation- along with identifying what factors actors in this arena are seen over the horizon. The data provides insights into how companies address industry changes through their business model as well as reveal possible future trends in the industry. Given that the future is difficult to predict, the aim of the research is to uncover what 3D printing informants view as the future factors rather than what they currently are.

3.1 Research Strategy.

3.1.1 Research Purpose.

As the aim of this study is to understand the future emergence of 3D printing, an exploratory approach is best suited for uncovering insights into 3D printing business models, mass customisation, and future trends. With many 3D printing applications still on the rise in the hype cycle and some settling into the norm (Shanler and Besiliere, 2017), it is interesting and important to explore how companies are reacting to changes in 3D printing. Thus, an exploratory study fits this purpose by means of using open questions to discover what happened and what is happening to provide insights into the emergence of 3D printing (Saunders et al., 2016: 174). As this research piece aims to focus on informants in the 3D printing community in the UK and understand what is happening and what may happen, an exploratory study better suits discovering the current scenario and gaining insights on future trends. Given that the current literature on business models is so theoretically varied and the literature specifically focusing on 3D printing companies is limited, this exploratory research will provide a 3D printing community perspective.

Initially an explanatory study or combined studies approach was considered, but given the broad topic of business models and future scenarios, a combined approach would have been too cumbersome given the time limit and subject matter. An original research aim focused on explaining how 3D printing companies innovate their business model. However, as it was shown in the literature review that business model innovation includes unintentional changes, an explanatory study was rejected as identifying and explaining the causal relationships may be too difficult and uncertain. A combined study of exploratory and descriptive research was also considered. However, given the variety of topics to be explored- business models, mass

customisation, and future trends- and how business models can constitute unintentional actions and process, using a descriptive research approach may not provide an accurate and in-depth description of the company's business model.

3.1.2 Research Design.

A qualitative research design is undertaken for this dissertation fitting into an interpretive paradigm. This design better suits an exploratory study. Given that business models are subjective topics, a qualitative approach allows for better investigation into the different interpretations and applications of business models and future factors.

A qualitative research design utilising an interpretivist paradigm provides a means to highlight another perspective or reality of business models to the literature. Based on the literature review, business models are a subjective concept with each academic and person using and understanding them differently. An interpretivist approach allows the researcher to take into account the perspective of the subject and highlights multiple perspectives with the basis that there are series of realities, each of which provides its own understanding and interpretation (Remenyi et al., 1998: 35). This in turn provides greater insight into 3D printing companies and what they view as influential factors for the industry and their business (David and Sutton, 2004: 44). Though taking a positivist approach may prove better at identifying and understanding the effects of specific variables, the very nature of controlling an investigation leads to a simplified version of the real world (Remenyi et al., 1998: 35-36), whereas an interpretivist approach provides consideration of complex nuances in the day-to-day.

However, a major drawback from this approach is the lack of objectivity and generalisability. As there is no single objective reality in this approach (Remenyi et al., 1998: 35), the subject's own interpretations can be considered inaccurate or conflicting with another's observations. As part of this study aims to identify future trends and factors in 3D printing, the trends and factors identified in this sampling may not prove true for another group. Also, each participant's subjective understanding of what is likely to affect the industry and their company may never actually realise. This is also an issue in studying future emergence - whether or not the findings will be realised is currently unknown. As this approach relies on understanding the subject's view of a phenomena, generalisations are unlikely or highly limited. Primarily generalisations from this approach are along the lines of stating that an event or phenomena exists or existed, and it is likely to occur again (Remenyi et al., 1998: 35). Also, a note of caution: since this research's aim is to explore participants' view of the future, the trends that may emerge may not necessarily come to fruition

as the future cannot be predicted. It still, nonetheless, provides insights into the areas that participants perceive to be the most influential and important. Despite these issues in using an interpretivist paradigm, it does showcase a unique perspective in regards to the phenomenon that is the 3D printing community in the UK.

3.1.3 Data Collection Design.

The data collection design utilized a multi-method qualitative study to aid in discovering a variety of themes. Multi-method qualitative study allows for collecting data with multiple techniques; in this case, observations and interviews are used (Saunders et al., 2016: 168). Despite multi-method studies also including multiple data analysis techniques, only one data analysis method is utilised given the large amount of data that is produced using multiple qualitative methods. The main advantage of this data collection design allows for varying sources of data and hence interpretations and perspectives of the same issues.

3.2 Research Method.

The research method of data collection is through observations, specifically participant-observations, and semi-structured interviews. Participant-observation occurred at the Going for Gold (GfG) conference at Bournemouth University, while semi-structured interviews were carried out with various members of the 3D printing community in the UK.

3.2.1 Observation-Participant.

The use of observation-participant data collection produced insights and access to a variety of 3D printing actors and provided a legal viewpoint to the emergence of 3D printing.

The event that was observed was the GfG conference at Bournemouth University in March 2017. The conference's main purpose was in examining the IP implications of 3D printing. The itinerary included a presentation on Prof. Dinusha Mendis' (conference organizer and researcher) latest research preliminary findings, and panel presentations followed by questions from the audience. There were three panels, each with three presenters. The talks were all recorded with all participants being notified that the conference recordings were to be available in the future.

The researcher's role was that of an observer-as-participant. The researcher primarily observed the participants. However, there was limited engagement with subjects. After panels, the researcher engaged in short discussions with panellists to clarify and expand upon presentations.

By partaking in this role, the researcher is able to concentrate better on the discussions at the conference and take notes while also limiting influence (Saunders et al., 2016: 360).

Observations provide new first-hand information but this simultaneously creates issues for generalisability of the findings. The main issues in using observations is in regards to validity and reliability (Ghauri et al., 1995: 57). Researchers can become so influenced by their environment that they are unable to take a neutral stance (Ghauri et al., 1995: 58). However, this is unlikely to be an issue as the conference was only a day. Another possible weakness of utilising observations from a conference is that the subjects are unlikely to be in their natural environments. Despite this, the conference setting does provide a means of observing subjects from various backgrounds with subjects clearly sharing their own views and experiences in the industry. A chart of the conference panellist can be found in Table 1. Overall, observations provide opportunities for various first-hand insights but the data collected presents unique situations which are difficult to generalise.

Going for Gold Conference at Bournemouth University Speaker Chart			
Panel	Speakers	Background	Speaker Code
A	Prof. Dinusha Mendis	Professor of Intellectual Property law at Bournemouth University and Co-Director of the Centre for Intellectual Property Policy and Management (CIPPM).	Speaker A
B	Ruth Burstall	Senior Intellectual Property Associate at Baker & Mckenzie LLP.	Speaker B
B	Lionel Dean	Creative Director of FutureFactors and research academic at DeMonfort University.	Speaker C
B	Dids MacDonald	CEO of Anti Copying in Design (ACID) and Vice Chair of the Alliance for Intellectual Property.	Speaker D
C	Damian Etherington	Senior Collections and Learning Curator at Ipswich Museum.	Speaker E
C	Frank Cooper	Senior Lecturer in Jewelry Technology at the Jewellery School, Birmingham City University and Technical Manager of Jewellery Industry Innovation Centre.	Speaker F
C	Andrea Wallace	Postgraduate Researcher and Ph.D. Candidate in Cultural Heritage Law for the CREATE Research Councils UK Centre for Copyright and New Business Models in the Creative Economy at the University of Glasgow School of Law.	Speaker G
D	Rob Smith	CTO of Digital Forming.	Speaker H
D	Michael Weinberg	Intellectual Property & General Counsel at Shapeways.	Speaker I
D	Nikolaos Maniatis	Founder and Director of Museotechniki Ltd. and Founder and Director of The Cato Bot Trainer Company.	Speaker J

Table 1. The conference speakers when referenced in the text are cited based on their speaker code.

3.2.2 Semi-structured Interviews.

The second data collection method used was semi-structured interviews of seven industry informants (Table 2). The semi-structured interviews were used to uncover in-depth insights and establish a case study of each participant. This suits the purpose of the study to uncover how 3D printing actors perceive the industry, but also arises issues of objectivity.

Interview Chart		
Interviewee	Profession	Service/Field
Participant A	Executive	Software
Participant B	Entrepreneur	Modelling Services
Participant C	Entrepreneur	Modelling Services
Participant D	Entrepreneur	Manufacturing Services
Participant E	Entrepreneur	Software
Participant F	Researcher	Engineering and Manufacturing
Participant G	Researcher	Economics and Intellectual Property

Table 2. The Interview participants with general background information.

Semi-structured interviews allow for flexibility while also ensuring some consistency amongst interviews. A set of predetermined themes with a list of key questions are created in preparation for the interview. This allows for more complex, open-ended questions that may not otherwise be used in structured interviews or surveys (Saunders et al., 2016: 394). It also provides for greater flexibility as questions can be changed, added, or deleted depending on the circumstances. Nonetheless, this still has issues of standardisation and bias which brings into question the reliability, validity, and generalisability of the data. Though this may be the case, the key themes and questions list would ensure some degree of standardisation and alleviate some bias issues. However, as the purpose of the research is to understand the participant's perspective and interpretation, the use of in-depth qualitative insights better suit the research aim than obtaining statistical generalisability (Saunders et al., 2016: 398).

The semi-structured interviews were carried out via telephone for five participants with two interviews carried out face-to-face. Telephone interviews were predominantly carried out to cover issues of access as well as cost-effectiveness (Sekaran and Bougie, 2013: 124). The use of telephone interviews helped to alleviate bias that may arise through non-verbal clues with the interviewer. Conversely, this lack of observation of nonverbal clues may hinder the interviews as the interviewer cannot see any cues that could suggest nervousness or confusion. This is a weakness for telephone interviews but a strength for in-person interviews (Sekaran and Bougie, 2013: 124). Another advantage of face-to-face interviews was that participants could show items and demonstrate services to the interviewer aiding in the researcher's understanding. All in all, telephone interviews were predominantly used to help overcome issues in access as participants were spread throughout the country, but where possible in person interviews were used. The content of the interviews covered themes of business models, business model innovation, mass customisation, and future trends. The questions were predominantly open-ended. Questions included asking participants to provide definitions of concepts, having participants explain their company, how it was formed, and how it has changed.

For sampling, opportunity sampling was used counteracting issues of low participation rate. A variety of subjects were contacted for interviews ranging from businesses, to academics, to lawyers that work predominantly in the 3D printing industry in the UK. The variety of subjects were contacted to ensure different viewpoints were collected. In the end, seven interviews were conducted with five business participants and two academics (Table 2). Seven was the sample number based on people who responded and was the number of interviews that were able to be conducted in the time span. This method of sampling is very easy but it does have challenges of generalisability (David and Sutton, 2004: 151). For instance, lawyers were not interviewed. However, given that the GfG conference included presentations from lawyers, data from that event is utilised to showcase the legal perspective. Though this sampling method does not guarantee generalisability, it is easy and a variety of participants were interviewed to ensure multiple viewpoints.

As for ethics, all interview participants' consent for interview and recording was obtained in emails prior to the interview. All participants were provided the opportunity to opt-out of the interviews and study at any point. Also, all interview data collected was anonymised ensuring confidentiality, thus adhering to the University of Edinburgh's research ethics Level 2 (The University of Edinburgh, 2016).

3.3 Data Analysis.

The data collected from observations and interviews is analysed thematically bringing to light the main themes concerning how actors perceive business models and the future of 3D printing. The thematic analysis is carried out by coding the qualitative data in order to then build themes (Sekaran and Bougie, 2013: 339). This aids in discovering patterns of themes across all the interview and observation data. This method of analysis suits the research as the study focuses on meaning, trends, and ideas of the participants (Eriksson and Kovalainen, 2008: 219). Also, it provides a systematic and flexible analysis approach, beneficial for analysing the large data set (Saunders et al., 2016: 577). The themes presented are based on repetition of data, indigenous concepts, and metaphors used by the participants. Overall, utilising thematic analysis for the data provides a systematic and flexible approach allowing interesting themes to emerge from the data.

4. Findings.

After attending the GfG conference and conducting interviews with seven industry informants, the topics covered in the fieldwork included discussions about IP law, 3D printing technologies and advancements, business model conceptions and constructions, and value. The conclusion drawn from this data was an overarching theme about uncertainty supported by four sub-themes each with minor-themes (Table 3).

Overarching Theme	Sub-Themes	Minor-Themes
How 3D printing actors make sense of the uncertainty surrounding business models and future technical adoptions.	Business models as communication tools.	Business models as processes of making profit.
		Business models to communicate business vision or ethos.
		Business models communicate the company's value proposition.
	Varying sources of business model innovation.	Networks as an innovation source.
		Market changes as innovation signals.
		Personal Development.
	Uncertainty in design rights distribution.	Uncertainty in Defining Value.
		Uncertainty in Intellectual Property Law.
		Design as a spectrum.
	Uncertainty in technical adoption.	Uncertainty in Mass Consumer Adoption.
		Uncertainty in Mass Business Adoption.
		Uncertainty in Mass Customisation Adoption.
		Search for the Killer App.

Table 3. An overview of the findings.

4.1 Overarching Theme.

The overarching theme uncovered in the fieldwork focuses on uncertainty of the current and future state. The theme is how 3D printing business actors make sense of the uncertainty in the surrounding business models and future adoption of the technology. The current understanding of business models and the future emergence of 3D printing technology remains clouded with varying interpretations, understandings, and predictions. How these industry informants understand and react to these uncertainties and unknowns varies, highlighting how business

models lack a solid, single theoretical base and the challenges of working with emerging technologies.

4.2 Sub-Themes.

From the overarching theme of how 3D printing actors understand uncertainty of business models and the industry's future, five sub-themes are found: business models as communication tools, business model innovation from varying sources, uncertainty in value ownership and uncertainty in technology adoption. These themes demonstrate how the actors are working in an environment lacking solid constructions and constant change. In light of this, each actor has developed their own unique understanding.

4.2.1 Business models as a communication tool.

The first sub-theme focuses on what a business model is. My findings for this pull heavily from the interviews as the GfG conference barely covered this area. The interviews revealed business models as tools to communicate the actor's own construction of a business model. This sub-theme is supported by three minor-themes where business models are used to: present the processes of creating profit, communicate the business' vision and purpose, and communicate the business' value.

As highlighted in the literature, there is no concrete conception, definition, or theoretical framework of what a business model constitutes as highlighted by Participant G (2:40): "The business model literature is so vague. Everyone has a different method for business models, everyone has a different way of categorising it." Thus, each participant has their own understanding of what a business model is and how to use it. In the findings, the businesses generally used the business model as a communication tool. What they communicate with the business model is determined by their own understanding of what the tool is for. This can be seen in the minor-themes, which are three distinctive views of what a business model is: structural, personal, and economic.

4.2.1a *Business models as processes of making profit.*

One of the minor themes focuses on business models as a structural tool. For some of the participants, business models are viewed as a means of expressing the processes and finances of how the company makes profit. It can encompass "a process of taking orders, producing goods,

and selling it” (Participant B, 22:23) along with “a plan of the financial calculations and models of how a business makes money” (Participant A, 9:45). The predominant reason that participants perceived the business model as the processes of creating profit is because they thought of the business model as a communication tool for funding and investment opportunities. Three participants specifically mentioned that they created a business model document highlighting the processes, finances, and projections for future funding and investment means.

4.2.1b Business models to communicate the vision or ethos of the business.

The second minor theme that business models are used to communicate the company's vision, ethos, and purpose. The business has a core vision or ethos and then justifies or explains that by developing a model. As Participant D (20:20) experienced while developing their vision, “Well initially it was just, as you could call it a vision. This is what I would like to the company to look like, this is the values of it. And then however, it's very difficult to communicate to others.”

In order to communicate this vision, business models are used by many of the participants to clearly communicate their vision and ethos to their customers as well as providing a reminder for themselves.

4.2.1c Business models to communicate the company's value proposition.

Similar to the first minor-theme, participants also explained how business models are used to communicate a business' value. As Participant D (10:58) described:

“...what is the value, the unique selling point, the value that the company is going to bring, what is going to be different, what is going to add value to the business and everybody's else's business. That was a centre, we built a model on that.”

Once the value propositions are established, the business model is then used to communicate what it is for its customers. Overall, from the business perspective, business models are utilised as communication tools to explain what and how the individual conceives a business model's purpose.

4.2.2 Varying sources of business model innovation.

Similar to business models, sources of business model innovation vary and differ with participants drawing inspiration and signals from a variety of sources. These sources of innovation are applied both actively and consciously while other sources tend to arise from unconscious development.

The sources of innovation identified in the findings emerged from networks, market changes, and personal development.

4.2.2a Networks as Innovation Sources.

Networks include customers, stakeholders, suppliers, partners, friends, and many others. Every participant mentioned someone in their network having an influence in how they changed their business. The primary network influencer for the participants were their customers. This emphasises the importance of customers to the participants: "It needs to adapt to the needs of our client. We listen to where people are coming from" (Participant A, 17:38). As for working with advisors and business partners specifically for the participants: "It was very much an exercise of talking with advisors, and with [the co-founder] and discussing what we should do, why we should do it" (Participant E, 30:43). The process of network innovation included not only speaking with stakeholders but identifying new key stakeholders:

"Looking at our key partners instead of having lots and lots of suppliers, we've maintained that down to a handful. The idea being is to again build up the opposite of the customer relations, the supplier relationships as well. So we have material suppliers, machine suppliers, both in traditional manufacture and 3D printing as well. Also looking at suppliers, not just here locally in the UK, but we also have suppliers further afield in Europe and Vietnam" (Participant D, 13:20).

4.2.2b Market Changes as Innovation Signals.

Another source examined market changes as signals for innovation. Participants indicated experiences in market downturns, market trends, and new opportunities as indicators and motives for changing their business model. The business participants discussed how constant surveillance of the market and industry as a means of identifying change signals:

"You need to be flexible to be able to go, 'Opf this is coming along. How does this affect us? How can we circumvent it or take advantage of it?' You need to be thinking this way all the time which means reading up on a lot of stuff, looking at a lot of stuff" (Participant E, 50:51).

4.2.2c Personal Development.

Lastly, an interesting source of innovation arises not necessarily from relationships or research but from the individuals themselves. The participating entrepreneurs noted that many of the changes in their businesses emerged from their own exploration and learning development. For instance, one participant cited that they changed their company's market focus from a corporate focus to the arts due to their own interests and passions (Participant B, 23:46). Participant C (25:39) explained that the motivation for changes in his business are mainly "... my own personal development in how I run the business." This demonstrates the impact of an entrepreneur's personal development on the innovation of their business model.

4.2.3 Uncertainty in design rights distribution.

Another predominant uncertainty that arose from the findings was in regards to value of IP ownership of a 3D design. This emerged from discussions in value ownership in customised and particularly mass customised designs. Is it the designer? The customer? A third party platform? The general theme that arose from interviews and the GfG conference was that this issue is convoluted and not well-defined. This is based on the minor themes of uncertainty in defining value, IP law, and views of design as a spectrum.

4.2.3a Uncertainty in Value Definition.

In understanding how the participants viewed value, each one provided varying definitions of value from value propositions, to utility and personal values. All of this shows how "value is such a vague word and means many things to different people" (Participant G, 11:22). Because of this, there is an ill-defined construction of value which leads to varying perspectives in application.

4.2.3b Uncertainty in IP Law.

This leads to the second minor-theme of how there is uncertainty in IP law particularly towards 3D printing and its applications. Because value varies in definition and is so vague, certain aspects such as utility to the customers and producer of using a mass customisation tool are not taken into account in the intellectual property (Participant G, 14:06). There is also a:

"Tension of legislation to meet IP challenges of the new technology developments... One does not want to be too hasty with legislation as it may constrain development or be far off the mark.... However, being too late to legislate can affect those whose rights were not

protected beforehand but were susceptible to the technology developments negatively” (Speaker A, Panel B 53:32).

All of which highlights a lack of clarity in current IP legislation as well as creating a debate as to what should be done and when.

4.2.3c Design as a spectrum.

Lastly, a minor-theme that emerged is that design is a spectrum. As Speaker I (59:40) said, “When you think about the collaboration [in designing] you have to think about it on a continuum.” This means that design is a continuum with different variables participating, particularly in co-creation and mass customisation. Because of this, some of the participants believed that value ownership reflects this spectrum as highlighted by Participant C (40:03):

“I’d say there’s actually nobody that owns it 100% that would be my take on it...I think it really does split down between the designer and the client. What it comes down to is who’s got the most input into the design.”

On the other side, there are participants who think it depends on the terms and conditions of the work and some view the designer as the owner of the value. All of this suggests that in design, particularly in 3D printing, the value ownership is unclear especially given that design is a continuum.

4.2.4 Uncertainty in technology adoption.

The next sub-theme that highlights the overarching theme of uncertainty is the uncertainty in the adoption of 3D printing technology. This emerged from conflicting viewpoints and evidence provided by informants on whether or not 3D printing and mass customisation are to receive mass adoption. This is more specifically examined in the minor themes of uncertainty in mass consumer adoption, uncertainty in mass business adoption, uncertainty in mass customisation adoption, and the search for the killer app.

4.2.4a Uncertainty in Mass Consumer Adoption.

The uncertainty in mass consumer adoption of 3D printing emerged from one group of participants and speakers highlighting how it is becoming increasingly feasible for 3D printing to become an everyday household item:

"I do see 3D printing coming down in price and becoming more available...it becomes unreasonable to have a 3D printer in one's home. There will become a new class of product where quality is okay, not sufficient for a retailer, but satisfactory for home" (Participant A, 24:29).

In addition to 3D printers, the supplementary technologies and tool such as "scanning and 3D design software are becoming ever cheaper and more capable" (Participant F, 39:58). Therefore, with advancements and usability improvements some participants forecast 3D printing receiving greater consumer adoption and use.

This view is conflicted with another voice on how consumer expectations of 3D printing do not coincide with current capabilities, cost, and skills needed to use the technology as explained by Participant G (22:27):

"There will be people who will tinker around with 3D printing, but I don't see that expectation that I can print amazing stuff at home has been realised for inkjet printers for photos, so why would it be for this one."

In addition to quality issues, accessibility, design, and software skills are still needed. For instance, despite CAD and other design software becoming easier to use "what they're not very good at doing just now is cleaning up the model before exporting" (Participant B, 58:46). This shows how extra steps and skills are needed to transfer a 3D design into a file that can be 3D printed. In addition, much of 3D printing remains expensive such as the CAD modelling packages because "... annual licenses and what not they run into the four figures quite happily" (Participant C, 35:50).

4.2.4b Uncertainty in Mass Business Adoption.

Then, the findings reveal a similar dichotomy of views with regards to the adoption of 3D printing by businesses. There is one view that 3D printing technology is improving and having increasing applications allowing it to be more massively adopted in industry and business. Speaker H (2:14) noted that "the barrier to entry on many productions has dropped, as one can create complex items more simply. You just have to be able to make a file and have access to a printer." In developments led to "the precision, accuracy, quality of the stuff that you get off having improved dramatically, and the price has tumbled" (Participant G, 14:21). All of which leads some to consider 3D printing "... the fourth industrial revolution allowing for easily, bespoke manufacturing and fine-tailoring manufacturing. Allows for a nearly infinite scope" (Speaker D, 30:29).

Despite improvements in ease, quality, and cost, some of the participants noted that there are knowledge gaps and industry hurdles which prevent 3D printing from being adopted broadly by businesses. As for specialised use, Participant B (51:25) summarises the experience of other participants:

"More and more we are combining 3D printing with other stuff...I do think the ability to combine stuff is really useful. I do think it'll find its place amongst a whole spectrum of other technologies and gets combined with them mostly. There are some jobs where laser cutting is just better at it and cheaper."

As for knowledge, some participants noted investing "more time selling the technology..." (Participant D, 9:58) than the business. Also, participants have sensed a lack of design and 3D software expertise amongst their clients. In addition to the knowledge gap, quality is an obstacle because "for it to be successful, it has to get to the point where we don't ever notice that its 3D printed" (Participant G, 25:37). Still, the technology is not there yet. Overall, businesses "...need to justify the use of 3D printing as it's expensive and time consuming for artefacts" (Speaker C, 15:08) with retail success not guaranteed.

4.2.4c Uncertainty in Mass Customisation Adoption.

Like the adoption of 3D printing by consumers and businesses, the adoption of mass customisation is also clouded in uncertainty. Two competing thoughts has emerged here as well. One perspective projects mass customisation becoming more of a norm particularly in consumer products. 3D printing supports mass customisation which is a "...a big selling point for brands and something that consumers may come to expect in the future" (Speaker B, 4:45). Similarly, Participant D (42:48) forecasted high value retailers bringing 3D printers in as a marketing drive:

"I see things like that, where companies will use it to produce something different, unique, and individual...Companies may start saying, 'Let's get a 3d printer on, so we can start doing things for our customers.'"

On the other hand, the other perspective is that mass customisation is unlikely to receive mass adoption in the consumer product sphere with it more likely remaining in niche markets. One reason for this that though mass customisation is mainly considered for consumers "... it's not something people experience. It has very specific product sectors where it makes sense [jewellery for instance]. For many people the convenience of a mass produced item is still so good..."

(Participant A, 27:08). Additionally, consumer expectations are unlikely to align with current capabilities and cost. As Participant C (53:08) explains:

"I would say that as people become more aware of it they'll use it. But I, the one problem I find is that we're so used to getting injection molded parts from China that cost pennies...The problem there people will want to do the customisation but they won't want to pay the associated price."

4.2.4d Search for the Killer App.

Perhaps much of this uncertainty of adoption of the technology and adoption of mass customisation may lie in the continued search for the killer application (app). The killer app is referred to as the application that can only be used with the technology. The application's unique features drive consumers and businesses to buy the technology in order to use the specific the application. The general consensus is that "...there is a feeling that nobody has quite discovered ...the killer app for 3D printing..." (Participant F, 1:36). Despite the killer app yet to arise, Participants F and Participant G suggested that possible killer apps included medical applications, dental, and topological optimisation.

5. Discussion

The initial research began as a quest to understand the future emergence of the 3D printing industry and how the actors perceive it. Using qualitative methods of semi-structured interviews and participant-observation data from the GfG conference, an overarching theme emerged of 3D printing actors dealing with a double ambiguity of technology adoption and business models resulting in various perspectives of the situation. Drawing on the literature on business models and value, I have sought to understand how these findings support or disprove existing theory as well as bring in new nuances. The 3D printing industry is very complex as actors use ambiguous business tools, challenge current practices, and prepare for an unknown future.

5.1 Business Models.

The findings confirm the initial overview of the literature: that there is no concrete definition or construction of a business model and because of that, there are different views to the purpose of business models. This confirms the aspects of my hypothesis that firms have varying conceptions of what a business model does and that business models are used as an explanation or communication tool. However, contrary to my hypothesis, I found that business models are not always used to communicate how an organisation captures and creates value. The findings support Baden-Fuller and Morgan's (2010) argument of how business models can be used as tools, along with supporting a structural and strategic view of business models like Amit and Zott (2012). It also simultaneously supports Doganova and Eyquem-Renault's (2015) argument, which presents business models as narrative devices.

The varied communication purposes of business models from the fieldwork support Baden-Fuller and Morgan's (2010) argument of business models as models or tools for varying purposes. The findings of how business models are perceived as a means of explaining how a company creates profit, communicate the business's vision and ethos, as well as revealing the organisation's value offering. These varied understandings of what a business model's purpose is coincides with their argument on how there is no single conception of a business model and how it can differ based on perspective and use (Baden-Fuller and Morgan, 2010). Given that models are tools to communicate complex ideas, the use of business models by the participants as a communication tool further support Baden-Fuller and Morgan.

Business model can be used to explain company structure and strategy. As a portion of the participants reported understanding business models as a tactic to communicate how their

business creates profit, it aligns with the structural perspective of business models as established by Amit and Zott (2001) and Osterwalder et al. (2005). As mentioned, participants who shared this perspective defined business models as financial projects and processes of running their business. However, other participants defined business models along the lines of company ethos indicating that business models are not solely structural frameworks. There are multiple constructions of a business model.

Business models reflect a vision and ethos. As some of the entrepreneurs used business models to justify and explain their company vision and ethos, the concept of value was taken out of the equation. This is particularly interesting. In practice, business models can be used without necessarily referring to value, whereas in the literature value is at the centre of the construction of a business model. This suggests that because value is a vague idea with varying interpretations, explaining one's business is easier without reference to value. Another view is that perhaps this suggests that value in terms of intangible benefits- such as customer service, quality, and empowerment- are considered ethos by some of the entrepreneurs and are thereby separated from value. To summarise, a portion of the interviewed sample interestingly utilised business models without reference to value, value capture, creation or value proposition, which differs from the literature, where value is the focus of the business model.

In turn, this reveals how business models do not fit a narrow definition, creating a sense of vagueness. They can be considered as business strategies, structures, and processes as well as a means to explain concepts- be it company ethos or the intangible business offerings. Since the purposes of business models vary, business models have then emerged in this sphere as a communication tool to bridge an entrepreneur's understanding and conception of their business with their audience. The ambiguity surrounding business models allows for sensemaking in organisations as demonstrated in Karl Weick's (1995) research. This space of uncertainty then supports a space of communication amongst actors by allowing a general framework without establishing great detail that may put off non-experts.

All in all, this highlights the continued lack of coherence of business model conceptualisation. The findings also perhaps demonstrate more clearly how in practice business models differ in purpose and use more so than in theory. It also implies that the variations in the literature and use of business models, have led entrepreneurs to create their own constructions. This in turn informs business model research, which leads to new and varying interpretations and constructions. It essentially creates a cycle of limited congruence in business model research and practice (Figure

1). Though this poses issues in comparison, research, and communication, it does provide opportunities for new interpretations and framework developments which in and of itself is exciting, such as one framework that focuses on vision and ethos rather than value.

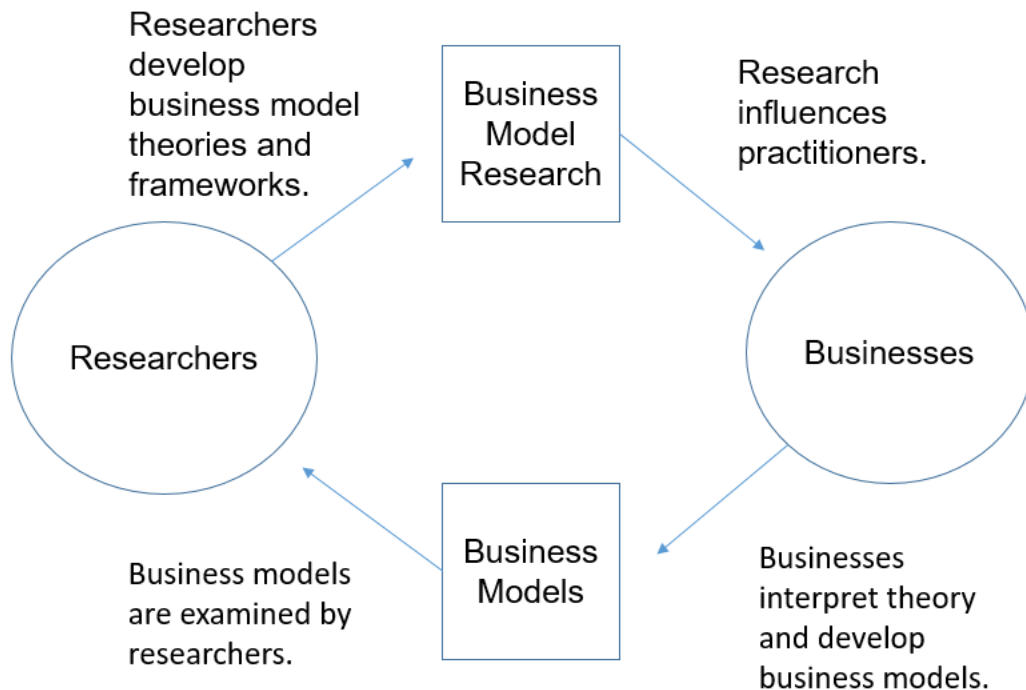


Figure 1. Cycle of business model research.

5.2 Business Model Innovation.

Similar to the business model hypothesis, my hypothesis that business model innovation can be approached through different avenues was confirmed. Not only was it confirmed, it was found that each business participant utilised various sources. Additionally, business model innovation occurred both intentionally and organically. This supports both views of business model innovation occurring in the strategic and structural realm like Geisen et al., (2007) as well as occurring through changing social constructions.

The strategic and structural business model innovations that arose in this sampling predominantly coincided with Geisen et al.'s (2007) industry and enterprise models. For industry model innovation, four interview participants stated how their companies are either expanding into new markets, increasing their customer base, or changing their customer and market focus. These changes can be considered industry model innovation because these companies are identifying

new opportunities in the industry. In fact, one participant identified a possible new market altogether: providing manufacturing solutions for small and medium-sized enterprises in Scotland (Participant D). This demonstrates the importance of market surveillance and flexibility in a business model to find and then adapt to the new market opportunity.

More interestingly, these business participants developed a keiretsu system. For many of them it was unintentional but there was evidence of developing special supplier relationships. Three of the participants would use 3D printing service companies (which would print a 3D CAD file on demand), and tended to use one company. Two of them reported undergoing a process of experimenting with different service companies and eventually finding their “go to” service provider. These two cases demonstrate how a keiretsu system can be created on a very small scale and unintentionally. On the other hand, one participant took deliberate actions in developing special relationships with his suppliers. These findings reveal how even small companies are utilising enterprise model changes to innovate their business model both intentionally and unintentionally along with showcasing how strategic networks are a valuable innovation source.

As for organic development and change, the social network factors additionally support social constructivist arguments. Such arguments are Doganova and Eyquem-Renault's (2009) findings of social interactions influencing the adaptation and development of business models, and Hamel's (2000) point that new models can be developed in value networks. All of the business participants cited speaking to customers, business advisors, or business partners as influencers in how they have changed and evolved their company. For instance, Participant B stated in the findings how change was driven by discussing the business with advisors and her business partner. This example in particular illustrates how each social interaction leads to adjustments and changes to suit that audience, as identified by Doganova and Eyquem-Renault's (2009). It also showcases how the actors are developing value networks. In fact, two participants mentioned that they have begun to receive repeat business and new clients from referrals. Furthermore, these examples evidence the influence of networks in innovation.

In addition, individual agency plays a role in innovation. The findings of how personal development has played a role for many of the participants in innovating their business model confirms Cavallante et al.'s (2011) emphasis on the role of individual agency. Multiple participants noted that, upon reflection, their own personal development has influenced changes in their business. Particularly for the entrepreneurial participants whose businesses are micro-enterprises and who run their businesses themselves, as they make changes almost seamlessly. One participant in

particular explained the enterprise's focus on corporate customers was changed to the arts due to her own interest and passion for the arts. All of this supports Cavalante et al.'s (2011) case of the impact of individual agency and illustrates how the entrepreneur is also an important source of business model innovation.

In summary, the findings support my hypothesis of business model innovation taking multiple forms with participants utilising various sources. It also provided examples of industry model and enterprise model innovation as set forth by Giesen et al. (2007). The findings also contribute new evidence and cases of how business model innovation can occur organically such as through networks interactions. Additionally, it supported Cavalante et al.'s (2011) case for the role of individual agency. This very much brings to surface how business model innovation can simultaneously occur intentionally and organically with actors being influenced from a multitude of internal and external signals.

5.3 3D Printing and Business Model Innovation.

The uncertainty around 3D printing growth and adoption in the literature and findings indicate that in terms of its evolution, 3D printing is still in its embryonic phase with no clear trajectory or path set out yet. This creates uncertainties and paradoxes in the industries. However, given that these insights are coming during this embryonic time, 3D printing is likely to become more certain in the future if the killer app or the best suitability for the technology is found.

5.3.1 Democratised Production.

A main theme in the literature stresses 3D printing as revolutionising manufacturing by decentralising it. The findings, however, suggest that for the industry actors this is not a main concern or excitement given how local manufacturing was mentioned by two participants briefly. Also, the findings around the uncertainty of adoption reveal the current obstacles of adoption and local manufacturing whereas the literature tends to focus on the feasibility rather than the actuality. This debate unveils a paradox of the 3D printing having low, easy entry barriers and operational barriers yet simultaneously being expensive and difficult. It is a paradox that is seen in the literature for decentralised manufacturing and the uncertainty of adoption in the findings.

There is a paradox of easy yet difficult access and operation for 3D printing. This is fuelled by greater accessibility to 3D printers but simultaneously, high quality machines are expensive and the necessary technical skills are limited. As shown by the two new startups in the sampling and

how the technology has improved and decreased in price (as mentioned in the findings), this proves that home fabrication is becoming more possible as the technology and quality become closer in reach and the community expands. However, quality and cost are still an issue, as noted in the findings, particularly for direct manufacturing. What may be holding back 3D printing in local manufacturing is low retail quality, higher product costs, and lack of consumer care.

In addition to hurdles to meet consumer expectations of quality and price, there is the skills aspect of the paradox. As uncovered in my findings, design software is becoming more accessible which supports home fabrication. In addition, one participant reported how art colleges are now educating students on CAD modelling (Participant E, 50:21). Nevertheless, the necessary software development skills are inaccessible with CAD modelling packages still being expensive. Design skills may be lacking and hard to develop with 3D printing design complexity being on par with high end graphic tools (Participant B, 57:43). 3D printing is reducing its skills intensity need while still maintaining a large investment in skills development to design and print properly.

Moreover, the literature and the findings present a paradox for democratised manufacturing. While 3D printing improves in quality and price, it becomes more accessible and feasible for mass consumer adoption, home fabrication, and direct manufacturing. However, this is coupled with current technical capabilities that may not meet consumer's expectations and is still investment intensive, financially and time-wise. The evidence for and against the democratised manufacturing trend aids in explaining the conflicting views and uncertainty in technology adoption.

5.3.2 New IP Environment.

A second theme in the literature regarding 3D printing trends surrounds the new IP challenges. Interestingly, in the interviews, IP was not of concern for most participants, as it was either not mentioned or the participants stated that they do not view it as an issue. This is supported by how most of the participants considered value ownership to be according to the Terms and Conditions or contract. Where this theme of new IP challenges strongly emerged was from the legal perspective primarily at the conference. The theme in the literature of future uncertainty of intellectual property protection coincides with the findings of uncertainty in IP law. As the possibilities of 3D printing are new and the current legal situation in the UK is full of gaps, what may actually happen in the industry is that "... the exceptions are going to define the rules" (Participant G, 16:48). The few cases that do emerge to settle this problem are likely to be the ones that define the new laws on 3D printing and IP.

Still, uncertainty and tension looms in the legal arena of 3D printing. As shown in the findings, there is a tension in the current legal sphere on whether to legislate or not to legislate new IP laws in response to the emergence of 3D printing. Based on Mendis et al.'s (2015) findings, the current status is a wait-and-see approach. Perhaps the answer for when to legislate will arise when those special legal exceptions emerge. However, until those exceptions are defined and the gaps filled, for now the legal aspects remain ambiguous.

5.3.3 Business Models and 3D Printing.

The third theme of 3D printing trends in the literature cautions the hype around a new technology and the importance of a successful business model. In terms of finding an adequate business model for 3D printing, there appears to be success with the emergence of various complementary businesses. In fact, two of the participants interviewed started their company less than a year ago and have already developed a client base proving that the technology is taking off and is successful for the time being. It does raise questions of whether or not the best business model or application for 3D printing technology has been developed yet and what will it be. What also comes to question is whether or not this emergent technology has actually created new business models.

In the findings, there is a theme of the search for the killer app for 3D printing. The search is still continuing with varying possibilities. Because the killer app has probably not been found yet, it provides an explanation as to why adoption of 3D printing is uncertain. It also supports concern of whether or not the current business models being used will continue to support the technology's current success. However, because 3D printing has become rooted in production as a prototyping tool (Rayna and Struikova, 2015) and participants have found 3D printing used more as a supplementary tool than an all-encompassing manufacturing means, 3D printing may have already found its place as a new technology to supplement activities rather than having a specific mass application.

As for business models, the 3D printing industry has led to the development of interesting business models. Although not discussed in the findings, many participants and speakers mentioned new business models emerging in the industry. One new business model is the emergence of 3D printing service companies, such as Shapeways, which sell, print, and deliver products for designers in an online marketplace. One participant suggested a model where businesses sell and produce products that can only be made through 3D printing. Some participants foresee 3D corner print shops emerging with models built around that service. Already

from Mendis et al., (2015), there are various 3D printing service platforms, software companies, and design companies. There are various other business models that were collected in the fieldwork highlighting how this technology has led to innovations in business.

Despite these new business models, questions concerning their level of innovation arise. Are these new models that are emerging in the 3D printing industry actually new business models or rather taking the same structures, processes, ethos, etc. from one industry and using them in another? Are these models innovative in that they are utilising an innovative technology or are they innovative in that these business models have never been seen before? Are these the best models to support the development and growth of the technology?

The answers to these questions remains uncertain. As stated in the findings, business models vary depending on one's perspective, therefore answering if these business models are new or not depends on one's interpretation. Additionally, due to the fact that the development and use of 3D printing has exploded fairly recently with the expiration of key patents, it is perhaps too soon to answer if these models suit the technology. However, these questions do provide opportunities for future research.

To summarise, the newness of the technology leads to uncertainties and paradoxes. The technology is more accessible than ever, yet high barriers to entry remain. The technology suits decentralised manufacturing, but at the same time, does not. The legal side remains clouded for now, or at least until the few, defining cases emerge. As for business models, the success and innovativeness of the business models emerging are also uncertain given the varying interpretations. All of which highlights the current embryonic stage of 3D printing.

5.4 Mass Customisation and Value.

When it comes to the IP or value of the digital aspect of 3D printing, there is yet another area of ambiguity. As in the literature, the legal perspective is also muddled in practice. From the business perspective the lack of clarity leads practitioners to heed to the status quo, terms and condition agreements, whereas the literature tends to favor the business. Like the new legal challenges, this area also remains vague. It is likely that once gaps in the law and questions in the debate are answered that this area will also become clearer.

From the legal perspective, the contention in the literature transpires in discussions of practitioners. As shown in the findings, the current legal situations regarding IP ownership of a

design remains uncertain with legislative gaps and vague definitions in British law. In the debate focusing on protecting rights holders and correcting social inequality (Menard, 2015), the findings reveal an actual tension of protecting and defining who the rights holders are without stifling creativity. Specifically, defining the rights holders and how much each rights holder is entitled additionally becomes convoluted. Since design and mass customisation are a continuum, the line between designer and customer become blurred as customers have greater input and creative liberties in the design. From this multiple questions arise. Should the customer be entitled to rights as they add their own creative input? Or should it predominantly remain with the designer as they create the file or software that enables the customer's input? Are current legislation and user agreements sufficient to handle this issue? The answers to these questions still remain uncertain but emphasise how 3D printing is challenging current positions and that the debate is focusing more on how to identify rights holders and protect creativity.

As for the business perspective, the lack of legal clarity leads to business actors to thereby default to practiced terms and conditions. The literature suggests that the design value would lay with the designer/producer as customisation is viewed as a value proposition for customers. Whereas in the interviews, participants believed that the value would depend on the level of input, similar to the debates in the legal sphere. However, in practice, the participants noted that value was according to the terms and conditions or the end user license agreements. This all implies that business actors are aware and consider the complexity of design and customisation as a spectrum or continuum, with customers also adding value and creativity through the customisation process. However, as it is a conundrum to determine how much each party has a stake to the design rights, the established practices are currently the easier and safer way forward. This, all in all, demonstrates how businesses are aware of the IP ambiguities and possibly willing to share the rights with customers. Until legal clarification is provided on these issues, it is likely that business will continue with the default.

5.5 Summary.

The British 3D printing industry faces double uncertainty with the technology and the business tools afforded to them. The findings emphasise the current issues revolving in the business model canon, a lack of consistent theoretical framework. This lack of framework, though, balances enough ambiguity and structure allowing the business model to still be utilised as a communication tool and providing new interpretations of business models, for better or worse. As businesses innovate their business models, innovation stems from deliberate changes and

organic developments through structural and social influences. All of this uncertainty, ambiguity, and vagueness in the industry creates paradoxes and conflicting views of the technology's future capabilities signalling how the industry is yet to mature. Nevertheless, as the technology matures and finds its place, the uncertainties in terms of application, IP distribution, and adoption are likely to settle with new practices and regulations to fill in the current gaps. Until then, the industry and its actors are working in an ambiguous environment creating new opportunities and challenges.

6. Conclusion.

To conclude, there is a double ambiguity for 3D printing industry actors. There is ambiguity surrounding business models and the future of the technology. The research confirms my hypothesis that participants would have varying perspectives and interpretations of business models and the future of 3D printing. In addition, how IP rights are determined and distributed for designs in mass customisation is complex, uncertain, and unlikely to be determined until legislation adequately catches up to the technology. However, the findings reveal these conflicting views and uncertainty, highlighting how the technology is still in its embryonic stage, but the current air of ambiguity is likely to settle once 3D printing finds its niche or killer application. Nonetheless, it also demonstrates that as the technology develops and finds its place, these areas of uncertainty and ambiguity create new opportunities and challenges.

The significance of the findings are that they provide new data and insight into the UK 3D printing industry. No previous research has been carried out as such. Additionally, the insights into technical adoption highlight both the factors that are driving 3D printing along with the major hurdles that 3D printing needs to overcome. All of which can support policy development and business practices. It also adds to the business model literature as it demonstrates how business models are perceived and used by emerging technology users, actors, and influencers.

6.1 Limitations.

One of the limitations from the findings is the sample composition and observation event. Due to access and time-constraints, the current sample of interview participants was used. Ideally the sample would include a legal professional, a 3D printing service provider, and, or a company that uses 3D printing for dental or medical applications. These additions to the current sample would have provided unique insights into the legal sphere that was not discussed at the GfG conference as well as perspectives from areas that are receiving increased hype around new 3D printing applications. As for the workshops used for observations, additional workshops or conferences would provide interesting observations and highlight other areas of interest and importance to the industry besides the IP implications.

As for research scope, the current study covered a fairly broad range of topics from business models to future trends and mass customisation. Thereby, changes in focus may have brought new findings. For instance, the research concerning business models could have been more focused allowing for greater details and insight into how the participants create and structure their

business models, along with any challenges in creating them. Currently, the participants were not asked exactly how their business models were formed nor what their current challenges were. This may have revealed more detailed insights into the current challenges in the industry and development of business models.

6.2 Implications and Future Research.

All of this uncertainty in 3D printing expressed by industry informants brings about implications for both academics, legal practitioners, and businesses. Much of this ambiguity allows for opportunity of future research and serves as a caution sign for the industry.

The first implication is for further business model research. One area should focus on greater clarity on the theoretical business model construct. Currently, business model research lacks solid theoretical foundations permitting various interpretations. However, the ambiguity surrounding it creates a positive space for discussion as actors come together from different interpretations but are still able to communicate with others as suggested by Weick (1995). There is a common understanding of business models as a communication tool to frame a business. On the other side, if there is too much structure, discussion amongst actors becomes halted due to lack of expertise in the subject. Currently, the findings suggest that the level ambiguity may be slightly too much creating difficulties in comparison and slight confusion amongst new business practitioners. Therefore, greater clarity in the business model canon would provide a means to benefit both researchers and practitioners.

A more specific business model research focus is on business models without the value. One area of interest that arose from the findings for future research is in examining business models without focusing on value. As explained, the literature varies in constructions of business models but there is still a concurrent theme of value capture and creation. Conversely, as shown in the findings, some participants viewed and used business models as company ethos and vision explaining tools rather than focusing on how the firm develops or obtains value. Future research could investigate whether or not business models can be developed without reference to value. Another research avenue could dive into the relationship between company ethos and company value acquisition and how the business model brings the two together.

Another business model research area is on business models for 3D printing. There is likely to be a need for future research into identifying and analysing successful and innovative business models. As explained in the discussions, because of the newness of 3D printing and the lack of

coherence on a business model definition, identifying truly new business models and whether they are successfully supporting 3D printing is difficult. Research into this area for digital technologies has been undertaken by the Business Model Zoo (2017) which classifies business models and researches how each type can be improved. Another aspect could focus on how the new technical innovations such as material developments and topological optimisation can be best utilised in 3D printing and what the business model would entail.

A second implication is a suggestion for study into the future shaping capabilities of workshops. The GfG conference provided a glimpse into how 3D printing actors utilise, perceive, and understand the technology from both legal, business, academic, and even cultural heritage institution perspectives. It also highlights the current trends, issues, and themes industry actors perceive to be important at that time. From a researching perspective, conferences and workshops provide opportunities to collect various perspectives from multiple actors almost simultaneously. As for future shaping, as these events bring together a diverse group of actors from different expertise, they create learning environments. For instance, one attendant at the GfG conference stated that he was attending to learn more about the IP challenges of 3D printing to better support his business. Moreover, conferences, workshops, and other events present great research opportunities to study future shaping by showcasing future trends and themes, bringing several industry actors, and creating learning opportunities.

A third implication of the research urges caution around hyped technologies and their capabilities. 3D printing has been called the fourth industrial revolution and some see it as democratising manufacturing. Nonetheless, as the research shows, these hyped aspirations have huge drawbacks preventing these fantasies from manifesting. A more critical eye of technological capabilities are perhaps needed when discussing and researching emerging technologies and innovations. Before mass consumer adoption or multi-industry implementation is hyped, the ideal application of the technology ought to be found first. For 3D printing this was found in prototyping. If the ideal application is found, the next stage would be then to consider why the technology has not progressed out of that domain. Despite the new uses of 3D printing in manufacturing, it is still largely used for prototyping which brings up the question of what is preventing the technology to be adopted for other purposes. Is it the current costs? The availability of materials? A lack of skills or knowledge? Overall, the hype surrounding a new technology needs to be met with a greater critical eye to understand the realities of the new, innovative capabilities.

To bring everything together, the implications for the research highlight opportunities and a need for future research. The research brings attention to the uncertainties surrounding actors in 3D printing, for business models, and future trends. These uncertainties need to be met with a critical and sceptical eye along with providing a new jumping point for future research in this and other emerging technologies.

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