How to match technological and social innovation: insights from the biomedical 3D printing industry

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Abstract: The purpose of this paper is to understand the transition from technological innovation to social innovation by analysing insights from the biomedical context. Specifically, the study investigates how entrepreneurs manage such a transition focusing on their motivations and awareness about social innovation. The study adopts a qualitative approach, in the form of multiple case studies of Italian firms that produce and use 3D printing in the biomedical field. Data was collected through in-depth interviews with entrepreneurs, backed by available documentary evidence and observation. This study points to the need for further investigation providing researchers with new information about the transition from technology innovation to social innovation. The transition has been studied from an exploratory perspective, considering 3D printing as a recent phenomenon in the biomedical field. Main results refer to social benefits resulting from the transition of technological innovation to social innovation, particularly focusing on the origin of such a transition.

Keywords: social innovation; technological innovation; biomedical sector; 3D printing; 3DP; entrepreneurship; entrepreneurial motivations; social outcomes; social framework; social entrepreneurship; additive manufacturing; healthcare sector; Italy.


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1 Introduction

Social innovation is a brand new stream within innovation literature. Actually, an increasing number of scholars in the management field are trying to shed light on this phenomenon (Christensen et al., 2006; Lettice and Parekh, 2010; Murray et al., 2010; Phillips et al., 2008). Social innovation has been widely defined as the introduction of innovative ideas aiming at social needs satisfaction (Mulgan et al., 2007). Actually, recent innovation literature stresses how new technologies can be a prompt for social innovation (Murray et al., 2010). However, scarce attention has been dedicated to the transition from technological to social innovation, except for a few attempts (Mulgan et al., 2007). Consequently, the aim of the study is to conceptualise such a relation through an exploratory analysis. Specifically, this paper intends to deepen the cause-effect relationships between technological and social innovation. Further, we want to study the role of entrepreneurs concerning social innovation with particular attention to their motivations.

In order to pursue this goal, multiple case studies have been conducted in the Italian biomedical district, where the 3D technology is adequately diffused.

The healthcare sector is one of the main fields where both social innovation and technological advancement are increasingly developing (Mulgan et al., 2007). Particularly in the biomedical industry, 3D printing (3DP) represents a breakthrough innovation from past technologies, allowing access to new healthcare treatments that are able to improve patients’ lives (Rengier et al., 2010). Hence, 3DP is an innovative technology that, when used in the biomedical field, may be interpreted as a dramatic social innovation resulting in social outcomes both at an individual and societal level.

The contributions of this article to the emerging social innovation literature are threefold. Firstly, the article deepens the scarce existing literature on the relationships between technological and social innovation. Secondly, the authors conceptualise a framework that shows the transition from technological to social innovation. Such framework highlights that the transition may be triggered by technology (‘technology-push’ perspective) or stimulated by unsatisfied social needs (‘social-pull’ perspective). Finally, the article analyses the role of entrepreneurs concerning social innovation by studying their motivation and awareness.
This study is articulated in six sections including this introduction. In the second section the article describes the phenomenon of innovation defining the concepts of technological and social innovation. In the third section, the article illustrates the methodology underpinning a qualitative research study. In the fourth section, the article presents the main findings. The two final sections present conclusions along with limitations and future research.

2 Theoretical background

2.1 Innovation and technological innovation

Traditionally, the role of entrepreneurship refers to the implementation and fostering of innovation and technological change (Schumpeter, 1934). Innovation is a wide concept that has been defined in a variety of expressions. One of the most cited definitions of innovation refers to Damanpour (1991, p.556) describing it as the “adoption of an internally generated or purchased device, system, policy, program, process, product, or service that is new to the adopting organization”. Organisational innovations in this way result from the implementation of new ideas or behaviours that contribute to the firm’s performance growth (Hult et al., 2004; Jansen et al., 2006). The role of new ideas is highlighted also by Van de Ven (1986, p.590) that defines innovation as “the development and implementation of new ideas by people who over time engage in transactions with others within an institutional order”.

The literature on innovation has proposed several classifications, among which we highlight three of the most significant ones. First, there is a distinction between product innovation and process innovation. Process innovation refers to innovative elements used in organisational operations, while product innovation consists in innovative products or services used in organisations (Adner and Levinthal, 2001). Second, there is a distinction between incremental and radical innovation, regarding the level of technological advancement provided to the organisation (Dewar and Dutton, 1986). However, according to Henderson and Clark (1990), this second classification is incomplete and potentially misleading because it is necessary to consider two other types of innovation: architectural and modular. Specifically, architectural innovations are the innovations that change the way in which the components of a product are integrated together without changing these components. In addition to these architectural innovations, which change only the relationships between the components of a product, there are also the modular innovations that change only the components or the core concepts of a technology (Henderson and Clark, 1990). Finally, we cite the distinction between technical and administrative innovation. On one hand, technical innovations pertain to products, services, and production process technology; they may concern either product or process and refer to the technical system of an organisation. On the other hand, administrative innovations involve organisational structure and administrative processes; they are more directly related to management and concern the organisational social system (Camisón and Villar-López, 2014).

Damanpour and Evan (1984) present a further distinction between technical innovations and technological innovations. The former concept is broader and covers the whole technical system of an organisation. Technical innovation modifies the way an organisation implements its socio-technical function of transforming factors of
productions into products and services, thus satisfying social needs (Fazzi, 1982). In such a perspective, technological innovation is a simpler concept referring to the introduction of new technologies in the organisation (Damanpour and Evan, 1984). Following Damanpour (1987), we will consider the concepts of technical innovation and technological innovation as synonyms. Henceforth, the term technological innovation will be used to indicate the introduction of new tools, techniques, devices or systems that produce changes in products, services or in the production process (Damanpour, 1987).

The use of new technologies can determine social outcomes, as Murray et al. (2010, p.16) highlight: “New technologies can be adapted to meet social needs better or deliver services more effectively. Examples include computers in classrooms, the use of assistive devices for the elderly, or implants to cut teenage pregnancy”. A person may wonder how technological innovations address societal needs, thus becoming a significant prompt for social innovation (Murray et al., 2010; Pol and Ville, 2009). Given the above considerations, this study wants to conceptualise the existing relationship between technological and social innovation, a scarcely investigated topic.

2.2 Social innovation

Recent management literature has progressively focused on the social aspects of innovation, giving emphasis to the concept of social innovation (Mulgan et al., 2007; Lettice and Parekh, 2010; Murray et al., 2010). Social innovation can be interpreted as “new ideas that work in meeting social goals” [Mulgan et al., (2007), p.8] and has been described as the employment of innovative products, services or ideas used to better address societal challenges (Lettice and Parekh, 2010). In respect to business innovation, social innovation can be described as a more complex concept mainly because social innovators are interested in satisfying a broader variety of stakeholders with different interests and expectations (Hall and Vredenburg, 2003; Lettice and Parekh, 2010). Social goals represent the ultimate outcome of such innovative mechanisms, which are characterised by high levels of responsibility towards damaged environmental areas and disadvantaged citizenship.

One of the main features that distinguishes social innovation from traditional business innovation refers to value-oriented attitude rather than classic profit maximisation paradigms (Mulgan et al., 2007). Hence, entrepreneurial motivations may be interpreted as one of the main discriminant elements between social or profit maximisation attitudes of entrepreneurs. According to Shane et al. (2003), entrepreneurial motivations represent the triggering factors of the whole entrepreneurial process. Entrepreneurial motivations can be both general – such as need for achievement, vision, and passion – and task-specific, such as goal setting and self-efficacy (Shane et al., 2003). Particularly, motivations can be interpreted as significant functional elements that foster the exploitation of entrepreneurial opportunities, which has been defined as “situations in which new goods, services, raw materials, and organizing methods can be introduced and sold at greater than the cost of their production” [Shane and Venkataraman, (2000), p.220]. For the purpose of the present research, these traditional aspects of entrepreneurs, namely motivations and opportunities, will be analysed through a social perspective. In line with Mair and Marti (2006), entrepreneurs are not only motivated by pursuing personal profit. In particular, social value creation has been considered one of the main distinctive objectives of social entrepreneurs (Mair and Marti, 2006), thus determining the generation of social innovation (Mulgan et al., 2007; Murray et al., 2010).
While traditional business innovation is generally motivated by profit maximisation, social innovation is characterised by a social value-oriented attitude (Mulgan et al., 2007). Hence, this article examines the entrepreneurial motivation and awareness both in technological and social innovation. Since technological innovations may produce social outcomes and increase social welfare (Murray et al., 2010). This paper investigates the role of technological innovation in producing social outcomes.

2.3 Social innovation in the biomedical industry

An example of innovation that meets social needs and creates social value can be found in the socio-healthcare sector (Mulgan, 2006). This is particularly evident in the healthcare field, where the social impacts of innovative technologies are immediate and extremely significant in respect to societal needs of both local communities and citizenship (Christensen et al., 2006).

In order to investigate the relationship between technological innovation and social innovation, we will analyse the use of 3DP technology in the biomedical sector. Such a sector includes all the technologies and products pertaining to health, with exception of drugs.

Therefore, this industry plays a crucial position in the healthcare field, thus developing a wide range of medical products and services. The biomedical industry significantly contributes to the increase of health systems’ effectiveness and its related disciplinary fields can be grouped into the following areas: diagnostics, treatment and rehabilitation, equipment and laboratory furniture and services (Viteritti, 2000).

Nowadays, high-resolution three-dimensional data imaging represents one of the most significant innovation drivers of the biomedical industry, resulting in the application of 3DP technology in the biomedical context.

If we look at an innovation in the biomedical industry, the discovery of a new drug can have positive social outcomes (Gardner et al., 2007). However, this study is focused on 3DP technology. We chose this technology because it is one of the significant growths in recent years.

Since our goal is to discover the relationship between technological and social innovation, 3DP appears appropriate because it is new, growing, and produces social benefits (Boisvert and Adelstein, 2015; Lee et al., 2015); these characteristics makes 3DP technology a good sample to infer the effect of technology on social innovation.

Particularly, 3DP first developed in the automotive and manufacturing sectors, while now it has progressively expanded in the biomedical field (Rengier et al., 2010). At this time in the biomedical field there are no other rapid prototyping systems. 3DP represented a radical innovation in this industry by allowing the building of custom made items at reasonable costs (Bartolo et al., 2012).

The basic principle of rapid prototyping systems refers to reconstructing physical objects in three dimensions. This allows the user to have a complete physical experience of objects. Under a technological perspective, in the biomedical field there are four rapid prototyping methods: stereolithography (SLA), 3D plotting (3DPL), drop on demand (DOD) and selective laser sintering (SLS). Regarding the first method, it is based on liquid resin polymerisation by laser. In this case, the laser creates the entire object through a bottom-up approach. 3DP method is instead comparable to an inkjet printer with the only difference being the main material used by the machine – thermoplastic polymer solidified into various layers. Then, DOD methodology is similar to 3DP except
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for the machine that simultaneously works on all three Cartesian axes, thus decreasing the
time needed for piece moulding. Finally, SLS methodology uses a laser to sinter or
‘solidify’ powder material, thus creating a solid structure. Finally, thanks to the
movement of construction base, an additional layer of material is added in order to create
the next object’s level (Dimitrov et al., 2006).

In the biomedical sector, 3DP demonstrates a significant improvement in diagnosis
and treatment activities (Rengier et al., 2010). Consequently, the possibility to increase
medical operation accuracy is guaranteed thanks to the simulation of complex surgical
phases of prototypes and models. However, the most significant application of 3DP refers
to the materialisation of ready-to-use biomedical implants. As a result, 3DP allows the
creation of custom-made products ready to be directly implanted in patients, e.g. dental
restoration, femoral reconstruction (Harrysson et al., 2007), craniofacial maxillofacial
surgery (Wagner et al., 2004), neurosurgery (Giesel et al., 2009), and cardiovascular
surgery (Armillotta et al., 2007).

While the introduction of 3DP in manufacturing firms merely represents a
technological innovation, in the biomedical sector such a technology can be interpreted as
a social innovation fostering social outcomes. These latter refer to operation risk
reduction, operation costs reduction, and finally less hospitalisation and rehabilitation
time for patients. As a result, two large orders of consequences may be individuated:
individuals’ life improvement and, in addition to this, community benefits thanks to
better socio-health conditions (Sokol et al., 2005; Leal et al., 2006).

3 Methods

The research objective is to fill a gap in the innovation literature by examining the
transition from technological innovation to social innovation in the biomedical 3DP
context. Specifically, the study analyses how entrepreneurs manage such a transition
mainly referring to their motivations and awareness about social innovation. This
exploratory study has been performed with a qualitative methodology supported by
multiple case studies of Italian firms that produce and use 3DP in the biomedical field.
Multiple case studies have been conducted under the guidelines proposed by main
literature (Yin, 2004; Pratt, 2009). First, we carried out a thorough review of available
contributions in literature, both national and international specialised press, as well as in
newspapers, periodicals, web sites and forums. Then, an exploratory multiple case study
has been conducted on five Italian firms that produce and use 3DP in the biomedical
sector. This methodological choice rested on the general agreement that qualitative
research seeks to answer the ‘how’ and ‘why’ questions, and that the case study method
is a useful way of doing so (Yin, 2004).

Italy is the third largest producer of biomedical goods representing 11% of European
market, behind Germany (31%) and France (16%) and ahead of the UK (11%) and
Spain (9%). In Italy there are 532 biomedical companies and its turnover amounts to
about €6.2 billion, allocated as follows: €3.2 billion relating to biomedical sector
(telemmedicine and medical care), €1.7 billion to in-vitro diagnostic (laboratory
technologies and devices), €1.3 billion to electro-medical sector (including diagnostic
imaging and ultrasound technology). The 2011 Italian census found 3,037 firms that
operate in biomedical industry, almost 70% of which is concentrated in five regions:
Lombardy, Emilia-Romagna, Lazio, Veneto and Tuscany. These areas produce 85% of national sales.\(^2\)

We searched our cases considering the relevance of firms in the biomedical sector and their specificity about 3DP employment. We selected firms located in central Italy, precisely in the Tuscany region. Specifically, regarding this region, a preliminary research carried out on newspapers, innovation journals, and interviews showed that in this particular area one of the four most important industrial hubs developing this technology by applying it to biomedical industry is located. To confirm that, the aforementioned census finds 214 start-ups involved in the biomedical industry with almost 60% concentrated in four regions: Emilia Romagna and Lombardia, followed by Tuscany and Piemonte. This has convinced the authors that the sample, even though in a limited area, could represent a well-founded case for study of this technology and its effects.

In detail, our case study is composed of four firms that use 3DP machines for biomedical purposes and one firm that produces 3DP machines for biomedical industries and other markets. We employed three steps of data collection procedures building on Yin (2004): interviews, documentation, and observation. Woodside and Wilson (2003) concur that case study research should entail a multiple approach to data gathering. In-depth interviewing is a fundamental qualitative method performed through open-ended or focused interviews. We opted for semi-structured open-ended approach because the variables involved in the research were not clear also for the referring literature (Yin, 2004). Through such an exploratory method, the interviewers asked respondents for their opinions about events by probing for key constructs implied by their answers. Specifically, we conducted 16 semi-structured interviews with entrepreneurs, managers, and technicians of the five Tuscan firms. The resulting triangulated data allowed us to validate the veracity of data by comparing each source with the others.

Before conducting the interviews, we sought to gather as much information as possible about both biomedical 3DP technology and the business of our cases, via the trade press and relevant websites, in order to develop an overall picture of the situation that could feed into the organisation of the interviewing. Vis-à-vis interviews lasted between 30 minutes and one hour and were recorded. Transcripts were made within 24 hours. The first part of each interview was focused on the firm with a particular emphasis on its approach to the 3DP technology and the reasons that led to its implementation. Then, other questions were addressed to comprehend entrepreneurs’ motivations and their awareness about the transition from technological innovation to social innovation. The third step of the research was to deepen the findings of the previous stages by examining such case-specific documentary evidence as firms’ reports and records, plus any available descriptions of 3DP machines. As a final step, observations of each physical feature of biomedical firms were undertaken. Having completed the investigation procedures, we brought together all information and carefully made a comparison in order to point out the relevant and common aspects investigated, before coming to our conclusions about the findings and the answers to our research questions.

3.1 Sample description

In order to ensure privacy of our respondents, companies have been named with Greek alphabet letters (Alpha, Beta, Gamma, Delta, Epsilon).
Alpha firm is a central Italian small engineering, design and production firm that offers a wide range of services regarding prototyping and small production lots of high precision instruments for biomedical, aerospace, and fashion industry. The main business model consists in internal design and production with a very strong participation and co-working of customers. Alpha began using 3DP technology only for rapid prototyping in product design. Thanks to innovative technological advancements, the firm had the possibility to access new product combination through 3DP technique also in the biomedical field. Actually, the main business refers to biomedical custom-made prostheses' production, which involves surgeons and patients in order to have a complete custom-made implant designed around customised needs.

Beta is a Tuscan firm located in the biomedical district of Florence. The firm’s mission refers to the study and development of healthcare solutions by adopting biomedical and pharmaceutical technologies in order to achieve high levels of technicalities and social benefits. Beta creates for each specific project a network of collaboration with other firms in order to develop innovative products. An example refers to the use of 3DP technique for spinal column pathologies. Beta has sought the best technology to produce it thanks to its R&D process. In this case, the use of 3DP in the biomedical field has been prompted by unsatisfied patients’ social needs.

Gamma is a start-up recently established by three Tuscan entrepreneurs that developed an innovative production process for the realisation of medical custom-made devices thanks to 3DP technology. Gamma innovatively implements the development and modelling phases of medical devices, such as braces for wrists, while production phase is completely outsourced.

Delta is a Tuscany medium enterprise that combines 3D medical image-based engineering and 3DP solutions in order to develop orthodontic medical devices. The firm’s founders have pursued one main objective: developing products that add real value to a patient’s life. The phase of product development at Delta focuses on improving patients’ health by making innovative and less invasive products. Also in this case, Delta’s commitment to innovation and high-quality support, combined with the needs and desires of customers, succeeds in producing safer and less invasive products.

Epsilon is a Tuscan biomedical firm located in the biomedical district of Florence. The firm’s activity refers to technological automation. Recently, the firm has started the production of 3DP machines stimulated by one of its customers. Epsilon has an open-source approach in the production of 3DP machines, thus collaborating with Fab-Labs and university research units. It produces 3DP machines mostly for manufacturing sectors and narrowly for biomedical sectors. Referring to the latter sector, the main outcome of 3DP machines concerns biomedical braces and plantar systems. The production of biomedical 3DP machines has mainly been motivated by business opportunities rather than social objectives. Particularly, Epsilon decided to develop an already used technology in order to enter in a high growth and profit-seeking industry.

4 Findings and discussion

The findings of five case studies stress the transition from technological innovation to social innovation thanks to the adoption of 3DP technology. 3DP is a technological innovation that, when used in the biomedical field, may be interpreted as a social innovation resulting in social outcomes both for persons suffering health problems and
for society in general. Such a transition seems to require an incremental and not radical innovation (Dewar and Dutton, 1986), since it consists in an adaptation of an already existing technology in order to satisfy particular social needs. Main social outcomes refer to high levels of customisation thanks to ad hoc realised through prostheses, braces, and medical devices used for satisfying customers’ needs. Particularly, such a customisation determines not only a rapid adaptability of a patient’s body and better therapeutic performance, but also less recovery time and less invasive medical procedure, thus avoiding significant risks and collateral damages.

4.1 Social benefits of 3DP technology

Findings reveal that all the typology of products realised by 3DP technology may determine social positive effects on patients’ health, as already stressed before (Armillotta et al., 2007; Giesel et al., 2009). From the Alpha case study it emerges how the production of prostheses allows new medical operations not possible before. In particular, the main driver that prompted the Alpha entrepreneur to adopt this innovative technology refers to the possibility of gaining a competitive advantage over competitors, thanks to products’ customisations and possible cost reductions of biomedical instruments. 3DP has allowed Alpha to offer a product that previously did not exist in the market at an affordable price. Other 3DP technology benefits refer to the anatomic shaping of medical devices that determine therapeutic benefits. Thanks to such characteristics also found in Gamma firm, braces are able to reduce patients’ recovery and rehabilitation time. As a result, 3DP custom-made braces show better characteristics than standard devices, although they are more expensive. Gamma decided to realise 3DP devices in order to exploit its high expertise in 3DP technology within the biomedical sector, where there are patients’ needs that can be satisfied with such an innovative technology. In addition, Delta activity shows high levels of customisation thanks to tailor-made solutions resulting in lower risks for patients’ health. The development of orthodontic medical devices originated from Delta collaboration with both dentists and prosthodontists, which necessitated a technology allowing better customisation. As a result, Delta’s founders decided to realise orthodontic devices through 3DP technology. These devices produce social patients’ benefits such as more comfort, less suffering and better efficacy.

3DP technology’s advantages such as less operational invasiveness and recovery times are common also in Beta’s intraspinal devices, in line with the firm’s mission consisting in developing innovative technologies that reduce patients’ risks and surgical invasiveness. Beta’s intraspinal device does not need to directly incise patient’s skin through an invasive cut, thanks to its specific percutaneous ability. It is important to highlight that the objective of creating a social product has been the prompt for enhancing already existing technologies in the biomedical field. This innovative intraspinal device is consistent with both Beta’s vision and mission: a well-suited balance between sustainable costs and social outcomes. The main advantage for patients is a less invasive biomedical solution with minor damages and health risks. From a technical viewpoint, Alpha, Beta, Gamma and Delta firms have confirmed the same advantages that literature has shown to beneficiaries of such treatment: in particular, according with medical literature (Rengier et al., 2010), we cite less patients’ bleeding, less bone tissue reduction, and acceleration of recovery times. Another advantage refers to a shorter rehabilitation time that goes to re-pay higher cost of this method.
Customisation is one of the main social effects observed in braces realised with 3DP, as it clearly emerges from Gamma and Epsilon cases. These braces also guarantee breathability and anatomic shaping that determine therapeutic benefits. Also in Delta’s orthodontic context the use of 3DP determines product customisation and less invasiveness for patients and better comfort.

4.2 Cost effects of 3DP

Concerning the effects of costs for patients and the healthcare system, case studies reveal that these costs depend on the particular product realised with 3DP technology. Alpha’s 3D printed prostheses are more expensive than standard ones, although they offer all the advantages described above. However, custom-made prostheses imply an advantage in terms of healthcare costs in the long term because they determine a shorter rehabilitation time and generally do not need to be replaced thanks to their longer service life in respect to standard prostheses. Instead, the intraspinal devices produced by Beta and orthodontic devices produced by Delta are cheaper than the alternatives already present in the market. A particular case refers to Gamma’s braces, which are more expensive than standard ones but cheaper than custom-made braces produced by other technologies. Hence, 3DP allows the reduction of price range existing between custom-made and standard devices. More generally, we could claim that in the long run costs for patients and health systems are reduced by 3DP technology. Finally, in Beta case it emerged how the reduction of productive costs allows the entrepreneur the provision of products to disadvantaged markets at a lower price. In this case, social outcomes are determined both by patients’ health benefits and by price decreases that allow developing countries’ patients to benefit from innovative technological devices.

Concerning the community benefits, Beta’s product is less expensive than its substitutes, thus allowing minor health expenditure. Consequently, it is also possible to provide such innovative technological products to disadvantaged areas that cannot afford expensive products. The possibility of developing a product with social outcomes and minor costs allows the Beta to improve its margins and, at the same time, to decide what the best price is for supplying the product in disadvantaged areas.

**Figure 1** Cost effect and social outcomes

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<th>Less</th>
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<th>Minor Cost</th>
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4.3 Technology push and social pull: a conceptual framework

One of the most significant results emerging from case study analysis refers to the relation between technological innovation and social innovation. It is possible to individuate two alternative frameworks, namely the ‘technology push’ and ‘social pull’, which highlight both entrepreneurial motivation and awareness about social innovation. The aforementioned framework builds on the ‘technology-push’ or ‘demand/market-pull’ paradigm described by Martin (1994, p.44) in the following way: “There is a distinction between technology push and market pull or demand pull. A technology push implies that a new invention is pushed through R&D, production and sales functions onto the market without proper consideration of whether or not it satisfies a user need. In contrast, an innovation based upon market pull has been developed by the R&D function in response to an identified market need”.

In the transition from technological to social innovation (see Figure 2), it is important to stress that when technology pushes social innovation we can talk about ‘technology push’. Instead, when social needs to pull new technologies or the adaptation of an already existing technology, it is possible to talk about ‘demand/market-pull’, which here can be defined as ‘social-pull’ innovation. Hence, in social innovation field the paradigm becomes ‘technology-push’ or ‘social-pull’. Figure 2 illustrates such a framework.

In the ‘technology-push’ side, an innovative technology with social potential pushes the entrepreneurs in pursuing social unsatisfied needs. In the ‘social-pull’ side, expressed social needs pull technological innovation resulting in social innovation.

Figuratively, Alpha, for example, began using 3DP technology for rapid prototyping in product design, and then it expanded its own business in the biomedical field. Alpha’s entrepreneur is aware that his work improves people’s lives and is proud of that, but no social motivation induced him in creating his business. The social purpose is the result of a choice but not
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the reason for the choice. As it clearly emerges from the words of the entrepreneur, “social innovation is just a positive side-effect that brings benefit to the community, but this result from the coincidence instead of my personal will. I’m glad producing benefit to the society but it is not the reason why I continue working in this industry”. Similarly, Gamma and Epsilon decided to enter in the biomedical 3DP field in order to exploit their own technological knowledge. In these cases, entrepreneurs’ motivations are not social oriented but they follow business logic in order to achieve diversification strategy.

In line with the above, entrepreneurial awareness about social outcomes in Gamma firm refers to the enhancement of patients’ medical treatment conditions. From the interviews, it emerges no explicit pursuit of social benefits. However, the outputs produced by Epsilon’s 3DP machines, such as braces and plantars, have social outcomes. The latter refer to high customisation and comfort for patients and better efficacy and performance regarding consumers’ comfort and healthcare treatments. Epsilon’s entrepreneur is aware about its products’ social outcomes, but social motivations do not represent the main driver for the business. This emerges from his words, “the production of 3DP machines for biomedical sector does not come from social motivation, and however at a social level we freely offer our products to universities and schools in order to support research in the biomedical field”.

In the ‘social-pull’ side, the framework refers to unsatisfied social needs that stimulate entrepreneurs to develop innovative technology in order to satisfy them, thus creating social innovation. In this case, social needs pull the transition from technological innovation to social innovation, alternatively generating a new technological innovation with strong social outcomes. This is the case of Beta, which decided to use 3DP technology to realise intraspinal devices with important advantages for patients. The entrepreneur is aware about its product’s social outcomes and his objective refers to the realisation of products that allow social outcomes at sustainable costs. The entrepreneur stated, “Social innovation is possible only if social benefits are higher than costs, otherwise we can talk about social marketing instead of social innovation”. Furthermore, Delta also began producing 3DP orthodontic devices following the demand of dentists and prosthodontists, in order to realise better-customised products. Actually, Delta has a team constantly committed in R&D activities aiming at high quality materials and new possibilities for customisation. Delta is convinced that many interesting biomedical research projects never get further than a planning stage, because of a lack of money. In fact, “[...] a major support by public institutions would be necessary for sustaining research projects with high social impact”. From these words, it emerges how Delta’s entrepreneur is aware about its products’ social outcomes. In this case, social motivation represents one of the main drivers for his business, rather than profit seeking. Finally, a significant cost reduction is possible thanks to 3DP technology in orthodontic medical devices.

In these two latter cases, entrepreneurs’ motivations follow not only business logics, but are also socially-oriented since the main objective refers to addressing unsatisfied social needs. As a result, Beta and Delta cases show how social motivation initially pulls the development of a new business. It is important to highlight that such businesses are profit oriented but, at the same time, they originate from entrepreneurs’ motivation to satisfy social needs.

According to the described framework, entrepreneurs of firms collocated on the ‘technology-push’ side seem to have less awareness about social innovation, mainly because they are predominantly focused on business and profit-seeking logics.
Entrepreneurs of firms collocated on the ‘social-pull’ side are aware of realising social innovation and, furthermore, are willing to address society’s unsatisfied needs expressed by the whole community.

Figure 3 summarises what we stated above: generally entrepreneurs are aware about social outcomes but are differently motivated regarding the firm’s final objective.

Finally, concerning the relation between technology and social innovation, extant literature on social innovation is mainly focused on the technology side, thus highlighting how technological advancement can represent a prompt for social innovation (Murray et al., 2010). The present study, thanks to the ‘technology-push’ and ‘social-pull’ framework, stresses how unsatisfied social needs can be a possible prompt for the transition from technological to social innovation. In fact, unsatisfied social needs can stimulate the development of new technologies or the adaptation of an existing one in order to satisfy social needs, such as in the biomedical 3DP context.

5 Conclusions

This article contributes to the existing literature on social innovation by first deepening the relationships between technological and social innovation, a scarcely investigated theme of research. In order to describe these relationships, the authors conceptualise a framework highlighting how the transition from technological to social innovation can be ‘technology-pushed’ or ‘social-pulled’. In addition to this, the article analyses the entrepreneurial motivations concerning social innovation.

As a result, the paper shows how 3DP in the biomedical field is a social innovation, because it is able to produce social outcomes. Specifically, the main benefits determined by the 3DP are products’ customisation and less invasive biomedical solutions with damages and health risks. One of the main findings refers to the conceptualisation of a framework that explains the transition from technological to social innovation, namely the ‘technology push’ and ‘social pull’. In the technology-push side, an innovative technology with social potential pushes entrepreneurs to implement it in order to address social needs. In the social-pull side, expressed social needs stimulate entrepreneurs to
develop innovative technologies in order to satisfy them, thus resulting in social innovation. Entrepreneurs of firms relating to the technology-push side are mainly focused on business profit-seeking logics showing scarce awareness about social innovation. On the contrary, entrepreneurs of firms relating the social-pull side are socially oriented since their main objective refers to addressing unsatisfied social needs.

5.1 Limits and future research

Evidently, the article suffers from many limitations. The main methodological limitation refers to a restricted number of case studies, thus affecting the representativeness of the sample. Besides, firms analysed are principally located in the Italian central area, in particular the Tuscany 3DP biomedical district.

Regarding future research, opportunities to investigate whether organisational, cultural, or environmental contingencies are likely to lead to a ‘technology-push’ perspective instead of a ‘social-pull’ perspective.

The goal of this research is to be an explorative starting point to understand a tangled forest of innovation studies, which might be integrated and developed in the future, not only in the innovation field but also in entrepreneur literature.

References


**Websites**

http://www.distrettobiomedicale.it/en

http://world-statistics.com

http://dati.istat.it

**Notes**

1 http://dati.istat.it (accessed 12/03/2014).

2 Data provided by Italian Biomedical Observatory, 2014 Annual Report.

3 Prostheses are artificial medical devices used to replace a missing part of the body, in our specific case we refer to orthopaedic prostheses that have to be surgically implanted.

4 Braces are medical devices that support a part of the body; in our specific case they support wrists.

5 We specifically refer to dental braces used for correcting teeth problems.

6 We refer to medical devices introduced into patients’ spinal column in order to solve spine problems.