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Industrial additive manufacturing service providers in Italy

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Purpose of the paper
In this paper we present the preliminary results of an ongoing research project aimed at appraising the economic, strategic and organizational features of Italian industrial additive manufacturing service provider companies. Although their activities are relevant from an economic and organizational perspective, no research findings are available at the moment for these companies or their business field, while the additive manufacturing technology has been devoted a great interest in engineering and materials studies. Service providers, however, plays a significant role in the integration of additive technologies in the manufacturing domain: apart from a few large companies that opted for direct investment, in fact, most of the components or products that are currently manufactured using additive technologies hail from service providers companies, both in prototyping and final production.

Theoretical background
3D printers are not a recent technology. In fact, their use in "rapid prototyping" in support of the development processes of new products dates back to the eighties as the first 3D printer has been created by 3D Systems in 1984. Starting from the second half of the nineties, however, this prototyping technology spread significantly in many manufacturing sectors including the automotive industry while over the last few years it is being adopted in final production activities too and become the top choice for some specific part in the aerospace, biomedical and automotive industries.
Even though additive manufacturing applications have been constantly growing for many years, the size of this market is still rather modest. According to the Wohlers Report – the main source of data in this field – its size amount to an estimated $3.07 billion turnover globally in 2013 (+39,5% compared to 2012) – clearly, a rather negligible volume if compared to the value of manufacturing at global level, which reached approx. $11.600 billion (World Bank). Sales, however, are expected to reach $4 billion in 2015, $6 billion in 2017 and exceed $21 billion in 2021, a growth that will be fueled partly by sales of under $5,000 "personal" 3D printers as a bigger factor will be the expanded use of the technology for the production of parts, especially in metal, that go into final products. The forecasts of an

expert panel engaged by the British Government (Dickens, Kelly and Williams, 2013), however, are definitely more optimistic: $100 billion within 2020.
On the one hand additive manufacturing should be seen in the broader context of "digital manufacturing" (Annunziata and Evans, 2013; Foresight, 2013; Brynjolfsson and McAfee, 2014). From different points of view, however, 3D printers are a further evolution of the potential of CNC machines. One of the most significant limits of 3D printers, however, is the size of the objects that can be built: one cubic meter in case for plastic objects and less than half a cubic meter for metal items. All in all, additive manufacturing is a radical and remarkably important innovation that is reported to be capable of producing deep changes in the economy and in society from multiple points of view (Rayna and Striukova, 2014). With 3D printing, in fact, new geometries are possible for many objects, stocks can be reduced and it can contribute to the redefinition of localization of production activities with different logistics, reorganize labour, create new professional skills in the area of manufacturing and the crafts, as well as new spaces for the creativity of individuals. On the other hand, this technological change poses huge challenges, inter alia, as of protection of intellectual property. Also, school and professional training should innovate in order to take advantage of this new technology.
These characteristics of additive technologies are raising great interest among manufacturing industries, which are attracted by the benefits that could be obtained particularly for pieces with a particularly complex geometry in small-scale applications and. Of course that is interesting for the Italian manufacturing SMEs. As a matter of fact, additive manufacturing develops the strengths of sectors where economies of scale are not the main success driver, but where promptness and rapidity of action are the winning factor. Most of these companies, however, cannot afford investments to the tune of hundreds of thousands for having professional 3D printers in house and their use of the technology would probably generate overcapacity in the short term. In fact, just a few SMEs are approaching to additive manufacturing with these arguments while early adopters rely on *service providers companies*, that is the object of this paper. That is the case for large companies too, however, as they usually go through different stages of adoption of additive technologies including an early phase of recourse to service contractors. According to contacts that we had with system manufacturers it can be estimated that service provider companies currently hold the biggest share of the total installed technology.
For all of these reasons these companies, their activities, their business models, their structure and the networks that are developing within their market space appear as really interesting research objects.

Research gap

For many years scientific research on additive manufacturing has been confined to engineering and materials studies while the topic has not been intensively researched by economic, management or organization scholars, whose interests should today be more significant than in the past since 3D printing applications are increasingly related to production rather than to prototyping.
The main actors in this field are system manufacturers, large industrial companies that adopt additive manufacturing in their production processes, and service provider companies. Each of them, however, is still kind of obscure object from an economic or organizational standpoint. The research group on additive manufacturing at the Department of Economics and Business Studies of the University of Genoa, nevertheless, is developing specific research activities in order to investigate this field and its main actors. Research gaps, however, varies within the three domains.

As of system manufacturers for industrial use, the Wohlers Report enlists 33 companies in the entire world: 16 in Europe, 7 in China, 5 in the United States and 2 in Japan. In Italy the most prominent entity in the field today is DWS (Digital Wax System), while globally the greatest manufacturers are: Stratasys, 3D Systems, Arcam, Eos, ExOne, Envisiontec, Renishaw, Bejiing Tiertime. As regards the market shares of the different manufacturers, it is not simple to rank them reliably as no sales data is available unlisted manufacturers. Stratasys and 3D Systems are the major players of the industry, with comparable annual turnovers of approximately $350 million (2012) , followed by Arcam (approx. $140 million) and ExOne (approx. $30 million). As to installed machines, the available data confirm that the market is dominated by Stratasys and 3D Systems, whose shares over the total units sold are 57.4% for Stratasys and 17.5% for 3D Systems, with the other manufacturers behind with substantially lower shares: 11.3% for Envisiontec, 2% for Bejiing Tiertime, and 1.9% for EOS. Significant growth trends are observed in the market of 3D printers for non-industrial use, often defined as "desktop printers", whose reference markets at present are the hobby and DIY industry, as well as small applications in the crafts and prototyping for small-scale architecture and engineering projects. Scholars in finance studies may be interested in detailing this picture.
As of large companies that are adopting 3D printing or service provider companies, however, the Wohlers Report is not very helpful. The research group is investigating this field: Beltrametti and Gasparre, in fact, provide an initial appraisal of economic and organizational rationale and their implications for innovation in the Italian manufacturing industry in "Industrial 3D Printing in Italy: preliminary outlook and future prospects", currently under revision for publication in the *International Journal of Manufacturing Technology and Management*. The most interesting application can be seen either in the consolidated field of rapid prototyping and in the direct production of parts for final use in the aerospace industry (the plant of AvioAero in Cameri is the largest factory in the world conceived for additive manufacturing) and biomedical industries (Lima Corporate is a leading company in the manufacturing of the so called 'acetabular cups' used in hip implants and the dental industry too is beginning to embrace this new technology). In these two industries, in fact, Italy is actually a global leader in the use of additive manufacturing. Other relevant application can be seen in the automotive industry, both for prototyping and direct production (in the racing sector). As of prototyping, in fact, additive technology has almost three decades of history in Italy as the first applications, in the late eighties, can be seen in the automotive industry either within Ferrari, Fiat, Lamborghini and Ducati. Other interesting application concern the jewelry sector as 3D Printing is now adopted in the direct lost wax casting of jewelry models.
The biggest research gap, however, concerns the business space of service provider companies. At the moment, in fact, apparently not a single scientific publication focus these companies, while either quantitative and qualitative aspects of their activities seems of primary interest for economics and management research.

Chosen approach

This research gap made clear an interest for launching a project on industrial additive manufacturing service providers. At the moment, the scope of the analysis has been confined to the businesses that operate in Italy. Also, we are not covering the "fablab" field as not part of the industrial domain. Also, the available technology is different as well as target clients: for industrial service provider companies it is professional 3D printers rather than low cost or entry level technology and clients are mostly enterprises (B-to-B), not individuals.
As of the data collection both quantitative and qualitative analysis is being performed as we are gathering date concerning installed technology, economic dimensions of different players, etc. as well as performing interview with each company in order to collect qualitative date on

5 different areas: company (economics, trends in the last 5 years, history, networks); technology (materials, 3D printers, other manufacturing technology, manufacturing processes, production capacity); people (staff with a direct involvement in 3D printing activities and back office, age, education, recruitment, turn-over, activities, working times, competences, training, skills); services (prototyping/manufacturing; design and reengineering, others); market (principal clients; industry specialization, marketing and communication, partnerships, future prospects).

Method of the analysis

The starting point has been the development of a database. For this purpose we consulted both the main system manufactures for these technologies and many Italian large companies that are currently using additive manufacturing in their production processes in either automotive, aerospace, packaging, biomedical and jewelry industries as part of previous research or direct request. Also, the research group could count on several insights from two important Italian service provider companies that were interviewed in the past. A few information have been collected on the internet too as 3D printing websites sometimes report information or advertising for service provider companies.

At the moment 38 companies have been successfully encompassed in the database. The process is still open however, but we are confident that all the relevant players have been included.

As of the analysis, at this stage of the research we can count on two different level of investigation: for all of the 38 we performed a detailed examination of available information on the internet, institutional websites, scientific journals or industry level publications. For 20 companies a direct semi-structured interview has been carried out from January to February of 2015. Data analysis, however, is still under way as just 9 company report have been completed so far. Although we will probably have more extensive coverage during the Workshop in May, in the next section we will present some very preliminary results, mostly based on the 9 cases.

Main findings and contributions

The first area of analysis covers *general information* concerning the service provider companies and their history. Date of establishment is available for 33 businesses at the moment: 14 of them were founded from 2000 onwards, 10 in the Nineties, 2 in the Eighties and 7 previously, but they changed their core business to additive manufacturing just from the Nineties. As of the 9 cases, we find out that they invested in 3D printing because their founders strongly believed in this new and relatively unknown technology and its business power. They tried new fields of application for 3D printers and sometimes even modified their technical processes in order to take full advantage of their potential. As of their business scale 4 service providers are small-sized enterprises, 3 are micro-enterprises and 2 are medium-sized. The latter, however, derive most of their turnover by traditional manufacturing activities.

As of *technology* one first aspect concerns the installed capacity: for the 9 companies it is 43 professional printers (17 for metals, 26 for plastics). As of materials just 3 of the 38 service providers specialize in metal materials (no plastics), 17 in plastics (no metals) and 18 companies cover both plastics and metals. As of system manufacturer and different type of technologies it can be said that most of the available professional 3D printers are installed and no specialization on particular additive technologies is evident. As of plastic additive manufacturing, however, Selective Laser Sintering, Stereolithography and Fused Deposition

Modeling are widespread while Direct Metal Laser Sintering prevails in metal additive manufacturing. Furthermore, it is significant that in all of the 9 cases traditional manufacturing machines are in use, whether in parallel non-additive manufacturing processes or in post-process activities for printed items. Post-processing machines, in fact, are adopted in 7 providers and this challenges the widespread idea that 3D printing does not need any finishing.

A second area of analysis is *people*. From this perspective it must be noted that staffing requirements is very low and in every visited company the number of workers employed in 3D printing is similar to the number of machines. Additive manufacturing require fewer workers than traditional processes and that is confirmed if we closely look at one specific service provider: they manufacture biomedical tools using both traditional and additive techniques in separate manufacturing lines but the additive requires way less workers while the value propositions of the two is very similar. As of educational background and skills that are required for these workers the scenario appear heterogeneous across the 9 companies. Most of these business, however, employ graduates, but only 2 organizations have job position reserved to engineers or graduates in physics or chemistry. In all of the interviewed company, however, one condition to be hired is clear as all require expertise in CAD software design. On the opposite, everyone is ready to invest in direct training for the use of 3D printers. At the same time, however, they seek for creative young people showing passion for innovation and desire to learn. From many aspects service providers looks like laboratories, where new ideas and technical solution are developed day by day.

Another area of investigation concerns *services*. As of this point 5 companies manufacture either prototypes or final parts, 3 specialize in just final parts and 1 in prototypes. Although data coverage is very limited at the moment, a move from "rapid prototyping" to "rapid manufacturing" seems in progress. One interesting aspect concerns design services. Not all the 9 providers design products for their customers; in fact some companies exclude this activity as they concentrate on manufacturing. Every service provider, however, needs to redesign objects, rethinking them in order to make their production convenient for 3D printing. This service, though, is offered for free by all of the 9 companies as they consider it part of the overall printing service or needed for marketing reasons as they can show to potential customers the benefits that they can get in turning from traditional to additive manufacturing. Re-design, however, usually allows spectacular breakthroughs for customers as energy savings or other results can be achieved. Also, re-design requires experience, technical skills and creativity. Not marketing these abilities seems questionable from a business point of view and reveals some weakness in these companies value proposition.

As of *market* strategy it must be noticed that sectoral despecialization is common as most of the providers operate in either biomedical, automotive, boating, design and construction fields. The research group has been reported pressure on the demand side and not significant competition. In fact, most of the interviewee claimed that they locate on a market niche, not facing any direct competition for their "unique" production. At this stage, in fact, potential competitors are working together in order to create long-lasting knowledge networks, to manage production peaks, downtimes and overcapacity issues. Competition, however, will raise in the next years and large service providers are emerging in the international markets, especially in Germany, United Kingdom and France. Also, new businesses are expected to enter this market as systems prices are falling. Furthermore system manufacturer are implementing downstream vertical integration strategies, by taking over existing service providers or founding new ones, and this looks as relevant threat for the smaller businesses.

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