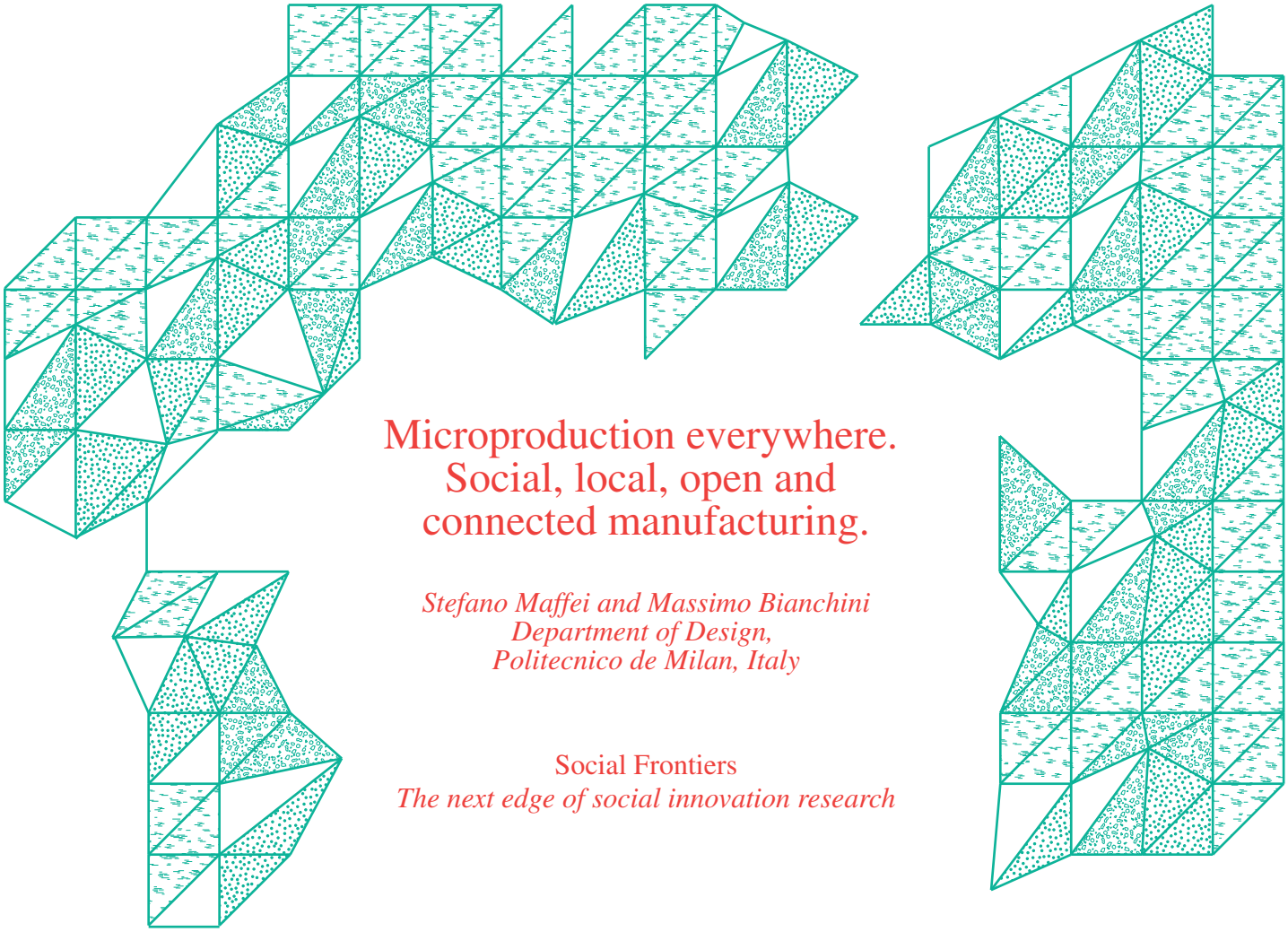

Microproduction everywhere. Social, local, open and connected manufacturing.

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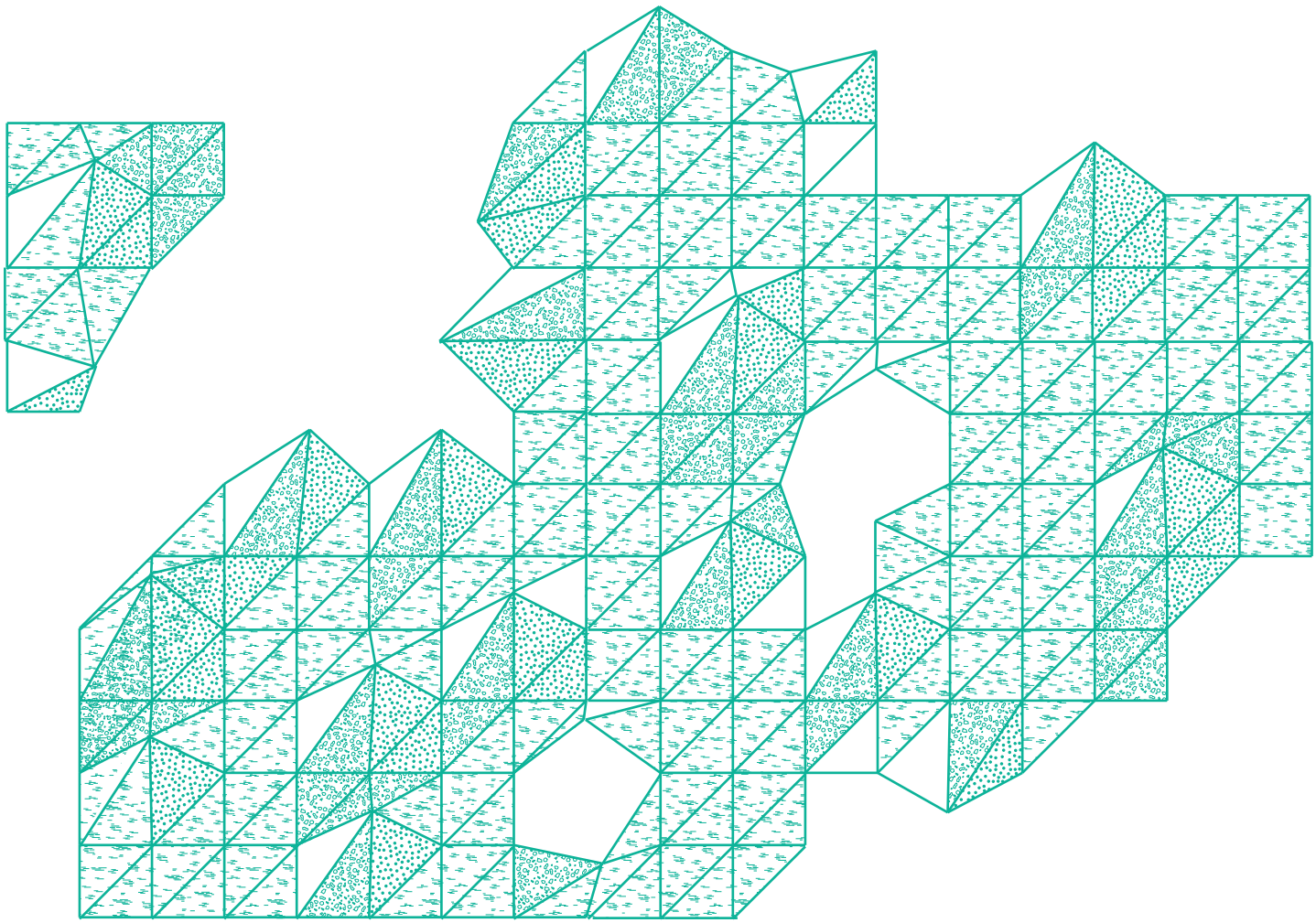

Microproduction Everywhere. Defining the boundaries of the emerging new Distributed Microproduction socio-technical paradigm.

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Keywords: Distributed Manufacturin g, Micro Production, Social Innovation, Indie innovation, Designer-Enterprise.

Abstract

The paper reports the current results of analysis and interpretation – from the standpoint of social innovation – of a number of studies[1] on the development of Distributed Microproduction (DM). A phenomenological reading of the new forms of small-scale production now developing in various disciplinary contexts – design, modern craft, 'Make' and DIY Culture – makes it possible to reconstruct the emergence of a set of ideas, processes, technologies, and shared values, and to hypothesise that DM can be interpreted as a socio-technical paradigm. It can thus generate new areas and paths of innovation. The first part of the paper defines DM, explaining its constitutive features and the factors driving its development. The second part extends the DM model by describing its systemic aspects in social and technological terms (Arthur, 2010). The final part of the paper identifies the linkages between DM and social innovation (Mulgan et al., 2012), which make a larger-scale merger of these two domains plausible, i.e. they build a Microproduction Everywhere perspective.

1 This is a set of educational experiences - research and pilot projects - some of which already ended (the pilot-project Analogico/Digitale, 2012, analogicodigitale.it/en/; Autoproduzioni Lab, 2012 and 2013, newitalianlandscape.it/designduepuntozero/), while others are in progress (the research MakeFactory, 2013, www.makefactory.org; an ongoing Phd research titles Design for Microproduction, 2011-2014, author Massimo Bianchini, and tutor Stefano Maffei), or are just starting (Close to Customer, a research funded by 7FP within the program Factory of the Future, 2013-2015, https://web.ttsnetwork.net/CTC/pages/index.jsp; La Filanda, a pilot-project for a micro-manufacturing hub, 2013-2015, recently funded by the Cariplo Foundation; and the research Cluster DOP - Distributed and Open Production on DESIS Network; from 2013, desis-network.org/).

1 Microproduction Now
1.1 Background

In recent decades, the main economic systems of the advanced West have undergone a process of deindustrialization brought about by the decommissioning and relocating of manufacturing activities from production sites in the great metropolitan industrial areas and from those of local production systems[2]. In Europe and the USA, these processes have disrupted the territorial (local and national) ties between production and distribution systems, bringing about changes in the relationship among the production, distribution and consumption/use of goods and services which have produced:

- a reversal of the power relations between manufacturing activities and those of (software) design and programming. The decline of the former has been matched by a growth of the creative industries[3], whose activities, as they change into the mass professions[4], fuel a surplus of cognitive stock, which is transforming numerous professional practices and roles;[5]

- the appearance of distribution systems alternative to the great shopping centres (which in the past caused the *distributive desertification* of cities) through the development of smaller distributive (*neighbourhood*) models of a decentralized, reticular and participative nature[6]. These experiences impact on the productive-commercial value chain. In pursuing carbon footprint reduction, they produce a culture of *product, process and technology-organization sustainability* based on networks and short value chains (0Km);

- in a saturated market, the changeover from push consumption models with new models of on-demand and tailor-made production representing an alternative to large-scale production. These originate from the growing demand for personalized and made-to-order products, which has arisen in response to the standardization of goods and the alienation produced by globalized production practices, with the intent of affirming a form of consumption which challenges the built-in obsolescence of products and their design quality.

As this atrophying of traditional production cycles based on outsourcing advances, and in so doing generates major transitions in labour markets7, now emerging are new socio-economic conditions which lay the bases for development of the tendency in reverse: namely insourcing.8
The purpose of insourcing is to slow down or halt delocalization processes so that it becomes ad-

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2 It refers to an extensive literature on the origin and development of industrial clusters and districts (Porter M., Becattini G., Rullani F. and Micelli S.), creative clusters and districts in urban systems (Landry C., Howkins J., Florida R., and Charter M.) and, more generally, on the evolution and transformation of these networks (Micelli, S.).

3 It refers to a large literature that includes activities classified by Florida R. (2003-2012), Hesmondalgh D. (2007), and Hawkins J. (2001-2005) and a range of official reports on cultural and creative industries issued by the European Commission (http://ec.europa.eu/culture/our-policy-development/doc/GreenPaper_creative_industries_en.pdf, last accessed September 25th, 2013), the report on creative economy by UNESCO, and national and international studies, many of which are linked to in the website of the European Creative Industries Alliance (http://www.howtogrow.eu/ecia/publications/page/2/, last accessed September 25th, 2013).

4 The designer and design theorist Andrea Branzi in many of his public speeches talked about the evolution of design from an “elite” profession to a mass and globalized job. See in Branzi A. (2010) Ritratti e autoritratti di design. Marsilio Editore.

5 ‘Designer’s Inquiry’ is an inquiry on the socio-economic condition of designers in Italy. (http://www.pratichenon-affermative.net/inquiry/en/, last accessed: September 25th, 2013). The Italian blog laureatiartigiani.it (craftmen-graduates) is collecting a set of experiences of young Italian graduates who choose to become artisans. These stories have several points in common with the approach advocated by M. Crawford in his book Shop Class as Soulcraft (2009).

6 The Global Retail Development Index, which is developed by AT Kerney (www.atkearney.com), measures annually the retail expansion worldwide and represents an interesting tool to observe the difference in the expansion of retail between emerging and advanced economies.

7 Mass unemployment, impoverishment, international conflicts on trade agreements, social dumping.

8 A recent interesting debate on insourcing appeared on The Atlantic magazine with articles by Friedman C. “The boom insourcing” (december 2012), A. Tonelson: ‘The Insourcing Boom That Is not’, as well as an article by R. Foroohar of April 2013 and published in Time titled “How ‘Made in the USA’ is Making a Comeback. Manufacturing is back - but where are the jobs? Another report Locating American Manufacturing: Trends in the Geography of Production By Susan Helper, Timothy Krueger and Howard Wial (http://www.brookings.edu/research/reports/2012/05/09-locating-american-manufacturing-wial, May 2012, last accessed: September, 25th, 2013).

vantageous for the great multinationals[9] and large-medium industry to resume the production of goods and services in their countries of origin. The governments of the USA and Europe are developing strategies and policies[10] that not only aim to bring manufacturing home through economic and fiscal incentives but also radically redefine the concepts of industry, factory, and production (and therefore of work and production technologies). They do so on the one hand through the top-down creation of a network of manufacturing institutes[11] to integrate communities of students, craftsperson, and small enterprises, stimulating them to design and test new products and production processes. On the other, they foster the grassroots development of productive communities and cultures whose most evident features are:

- the global movement of makers and technological craftsmen (Fig.1) which, through new forms of social activism, disseminates design and production practices connected with open design and digital fabrication;

- the rediscovery-rebirth of self-production both in the more evolved forms of Do-It-Yourself/Do-It-Together (DIY/DIT) and in professional and entrepreneurial ones[12] (Maffei and Bianchini, 2013) brought about by the evolution and transformation induced by the democratization of miniaturized and friendly technologies (additive machines, subtractive machines, design tools) that nourish the growth of a new handmade/digitalmade production boosted by Web marketing-distribution.

Fig.1 – The world of makers. The European Maker Faire in Rome. More than 35.000 visitors in three days , source: www.facebook.com/makerfaire

9 Multinational companies such as GE, Whirlpool, Otis and partly Apple are investing or have said they could be willing to return investing in production in the U.S.

10 The U.S. government has issued a report in 2012 to create a National Network for Manufacturing Innovation In Europe, the DG Innovation and Industry where he was active consists of the Association of the Factory of the Future (EFFRA), was prepared the report Design for growth and prosperity that has given much emphasis on micro-production. Also in the UK there is a lot of attention to this issue (Three Dimensional Policy: Why Britain needs a policy framework for 3D printing (October 2012) (http://biginnovationcentre.com/Assets/Docs/Reports/3D 20printing%%% 20paper_FINAL_15 20Oct.pdf, last accessed, September, 25th, 2013).

11 http://www.whitehouse.gov/the-press-office/2013/05/09/obama-administration-launches-competition-three-new-manufacturing-innova (last accessed: September 25th, 2013). These institutions are inspired by the model of the German Fraunhofer Istitutes. The first institute pilot contracted in 2012 is The National Additive Manufacturing Innovation Institute (NAMII). One of three new institutions is entirely devoted to the theme "Digital Manufacturing and Design Innovation".

12 The Authors have defined self-production and self-made design as "… a set of organised activities for the purpose of achieving new products/services through a process made up of strategic orientation/choice, design, construction, communication and distribution all implemented by the designer. These aspects may be carried out freely and in diff erent ways. However, they must co-exist systematically in order to truly classify as self-produced design. And this entire list of activities does not necessarily have to be performed in person by an individual or a group. Nevertheless, when these parties do not make the object directly, they must at least have organised/commissioned it…" in Maffei S., Bianchini M. (2013). Self-made design. From industrial to industrious design, in Ottagono, n.257 02/2013.

The development of these phenomena is in its turn enabled by a series of socio-economic and political factors, such as the increase in the urbanized population and therefore in local markets, combined with the decrease in purchasing power due to the employment crisis (the main cause of which is the closure and relocation of traditional manufacturing activities).
Also here, the radical transformation of the concept of leisure is a new production factor (Shirky 2010), which reactivates in citizens-consumers an interest in, and a propensity for, new forms of self-production and collaborative consumption, which induce local authorities to incentivize these processes. The end of the traditional hierarchical relationships and social subdivisions of the industrial and post-industrial age (Sennett, 2006) has led to the superseding of the conception of the factory and production as centres of conflict. Conversely, it has accelerated the transformation of ideologies into movements by channelling social protest into productive activism (e.g. makers and hackers) and craftivism (Greer 2008).

The convergence and interweaving of these cultures and phenomena is mainly evidenced by the growing redistribution and relocation of manufacturing activities, which is especially manifest in cities through the appearance of new forms of authentically post-industrial production. This concerns micro and networked forms – termed and – enabled by a new generation of actors such as Small (Urban) Manufacturers[13], Designer-Crafts[14], Designer-Makers (Schwarz and Yair, 2010), and Designer=Enterprises[15] (Arquilla, Bianchini and Maffei, 2011 e 2012). This is a population of small and extremely small personal enterprises - micro and indie capitalism (Manzini, 2011; Nussbaum, 2012) that make unique products in mini-series (tailor-made) through integrated and temporary processes of conception-production-distribution which blend the values of traditional craftsmanship with the logic of advanced production (Fig.2).
In these cases, design competences, which are closely bound up with technological experimentation, assume a central role in innovation processes (Bianchini and Maffei, 2012). Through high value-added analogue-digital manufacturing processes – many of them still tacit and informal (Nonaka and Takeuchi, 1995) – these new actors make design-oriented products expressly conceived and engineered for microproduction undertaken with more efficient and light fabrication processes. The small size and largely urban location of these enterprises bring them into direct contact with communities of customers so that they can build a strongly innovative and personalized product range (Friedman, 2011), while their parallel strategic use of the Web and social media enables them to expand these market-communities further. All this gives rise to a scenario for the possible growth of a new model in which the various microproductions are organizable on a larger scale (from a model centred on start-up to one centred on systemic scale-up).

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13 Mistry N., Byron J. (2011) The Federal role in Supporting Manufacturing, p.11 (a report developed by Pratt Center). Adam Friedman (Pratt Center) in his article on The Huffington Post (May 25th, 2011) entitled How to Make an Urban Manufacturing Boom wrote: "… SUMs tend to be small companies that produce very high value, design-oriented products. Their size and their location in cities keeps them directly in touch with their customers so they respond to the latest trends and demands in the market…"

14 UK Craft Council defines the main characteristics of the Designer-Crafts: i) Strong involvement of the owner or head of the enterprise in all steps of the workflow (financial independence, strong personal responsibility); ii) Craft, technical and management competences (apprenticeship as one means of passing on those competences); iii) Active contribution to production of products and services, iv) proximity to the client and local activities.

15 "Designer=Enterprises are independent agents who work with various design, production and distribution networks without being constrained by the need, even in the presence of a market success, to automatically make scale changes or stabilize their activities or products (thus becoming outright enterprises)". (Bianchini and Maffei, 2012; p.03)

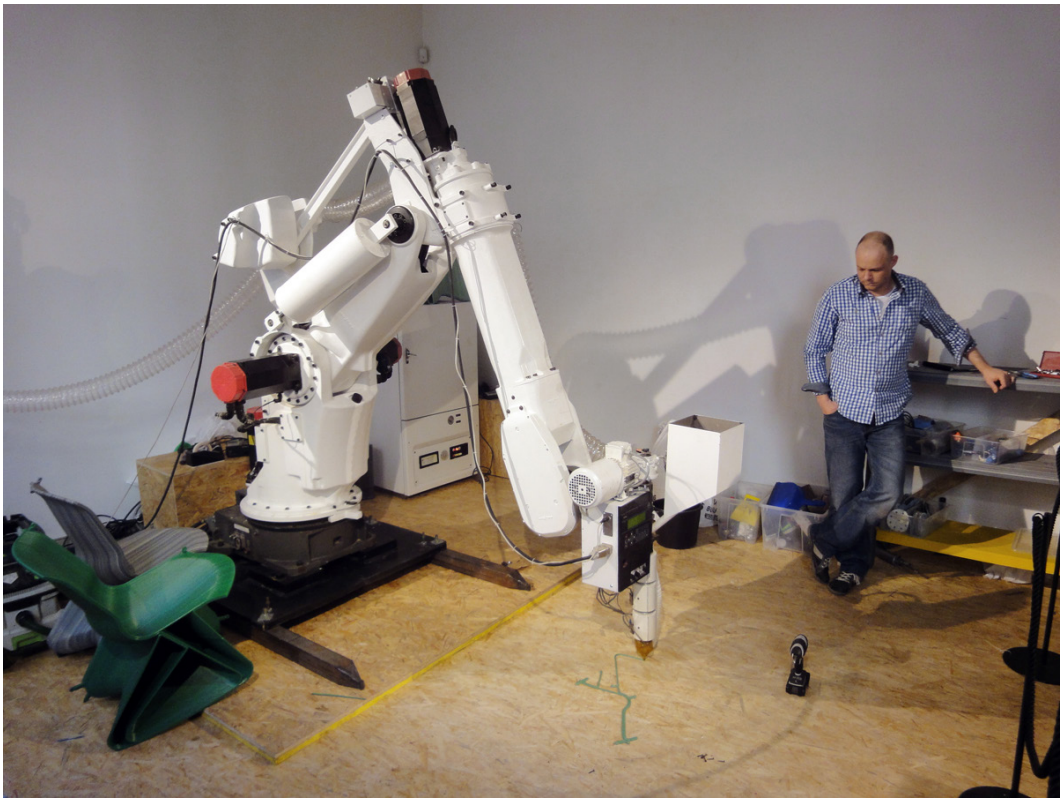

Fig. 2 – Dutch Designer Dirk Vander Kooji and his robot represents the concept of the Designer = Enterprise , source: http://2.bp.blogspot.com

1.2 Microproduction and the renaissance of manufacturing communities

When discussing the relocation of microproduction, it should be borne in mind that new manufacturing activities spring from, or establish themselves on, already-existing production systems often with consolidated histories. In some urban contexts, one therefore observes the cohabitation of more traditional (micro)productive activities with new and mixed patterns in transformation:

- microproduction historically connected with the classic craftsmanship which in the most traditional model was restricted to the assembly, repair or packaging of products (caterers, tailors, cobblers, carpenters, opticians) and which today have returned to forms of self-production;

- microproduction connected with crafts in sectors particularly responsive to the growing demand for the even extreme customizing and personalizing of products like vehicles (cars, motorbikes and bicycles)[16] and characterized by a strong propensity to convert industrial products into unique items;

16 In terms of tuning, pimping and all forms of individual custom-made and custom-built.

- recently-established microproduction connected with the great urban metabolisms (e.g. the agro-food sector17) that in a few years have seen the evolution of the model of community gardens into urban farms and the parallel advent of small production units like microbreweries,18microdairies,19 and equipment for an increasing community of farmers and growers;

- microproduction developed in the low-tech sectors of the creative industries (design, fashion, architecture) especially for fashion products and personal accessories, and household goods (furnishings, illumination engineering, household items, small domestic appliances, micro-architectures);

- microproduction developed in high-tech sectors with a historical or direct connection with large-scale industry and research (IT, robotics, mechatronics, plastronics, biotechnologies, etc.) and engaged in the experimental production of robots, drones, biomedical prostheses, materials, and machine tools;

- the growing and heterogeneous population (some thousands) of amateur and occasional microproducers applying the DIY/DIT approach also to the replication, repair, regeneration, redesign, or refunctionalization of existing products (fixers, remakers, refurbishers, customizers and hackers).

As proof of this convergence, a growing number of craft or amateur products viewable on platforms like Outgrow, Instructables and MakerFaire, or on platforms for crowdfunding20, achieve such a level of technological complexity and aesthetic sophistication that they are indistinguishable from mass-produced industrial products.
All this contributes to redefining the concept of MD in broader and more inclusive terms:

> "… a set of distributed practices and production processes geared to the materialization of material artifacts (or parts of them) in unique items or limited series, conceived with a purpose or a projectual intent, constructed and assembled by hand or fabricated using analogic and digital tools and machinery, in individual or community form, by a plurality of actors (amateurs, professionals and enterprises) in temporary or permanent premises of small size (not necessarily dedicated production sites) and therefore distributed in non-typologized ways and contexts."

MD comprises not only manual production and fabrication but also services, which range among the planning, distribution, promotion, and incubation/financing of the goods produced through these processes.

1.3 Distributed microproduction as an emerging socio-technical paradigm

The spread and the convergence of a growing number of small-scale production activities united by the peer-to-peer use of resources and fuelled by a plurality of product cultures foster the growth of new forms of DM (Rifkin, 2013). We may therefore define the latter as a coherent set of independent production organizations and activities physically distributed in certain geographical areas (mainly cities), connected and interacting through networks and platforms that facilitate the exchange of data and know-how (on design, technical and technological), and with the capacity to recast/reinterpret the culture of the places in which they reside. DM can be considered a multi-

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17 The UN estimates that 800 million people are engaged in urban agriculture in the form of friend gardens, family gardens, community gardens, corporate gardens worth 15-20% of the world production of food.

18 Douglas W. Murray, Martin A. O'Neill, (2012) "Craft beer: penetrating a niche market", British Food Journal, Vol. 114 Iss: 7, pp.899 - 909

19 In the city of Milan in the last 3 years have produced some urban dairies (e.g. www.centrodellamozzarella.it/) while in many cities - from New York to London - increases the production of honey.

20 The Crowdfunding Industry Report by Massolution evidences that Crowdfunding platforms raised $2.7 billion and successfully funded more than 1 million campaigns in 2012. Massolution forecasts an 81% increase in global crowdfunding volumes in 2013, to $5.1 billion.

agent system (Ferber, 1995), which expresses a design and distributed productive intelligence[21] enhanced by its relationship with the Web[22].
This type of distributed production organization exhibits a form of coopetitive behaviour driven by relations and by the online connection and organization of the individual organizations to address the needs of individuals and the market that they generate[23]. In contexts where the number of interactions among these actors significantly increases, there develop new productive approaches (relative to processes, techniques and organization) that represent the emergence of a socio-technical paradigmatic frame. From the socio-technical point of view, DM, like other distributed systems, has a set of general properties (Tab. 1).

Tab. 1 – General properties of Distributed Microproduction

Flexibility	It is able to create diverse configurations of actors and connections in the realization of processes to 'modulate' production: producing the same product in a different way, producing different types of product, different versions of similar products, or of the same product (variants or multiples).
Scalability/Adaptability:	It is able to have production processes vary (unique items, small series or 'multiplied' products, batches as the sum of small serial products). At the same time it is able to expand or shrink in size (number of nodes) and geographical extent (of the network). Moreover, the processes or practices (technological, organizational, social) that originate a specific productive context can be replicated and adapted for transfer to other contexts.
Transparency:	Productive processes and performances are trackable, visible, comprehensible, and shareable. Moreover, the system enables the constant development of applications for the info-visualization and monitoring/control of resources ('maker maps') in relation to the increasing incorporation of control devices1 and technologies in products and means of production.
Interoperability:	It enables a diversified set of production competences and skills to coexist and cooperate. It promotes forms of active cooperation between people and traditional and automated production systems (human integration and friendliness, Kühnle 2010).

21 Taking the concept of creative intelligence developed by Bruce Nussbaum, we can say that the DM is an intelligent or smart) activity in which the purely production (making) enters into a broader process that involves new skills: i) extract and distil useful knowledge from different fields (knowledge mining); ii) build scenarios and narratives to locate and make sense of the production activity (framing), iii) play with production through actions of simulation and not only disguising technology (playing); iv) exercise new forms of leadership with the parties involved in various capacities in production: partners, audience, customers, fans, friends (pivoting). The DM promotes new forms of independence that traditional circuits of production and mass consumption (even in a logic of downshifting) do not have, and works in places such as cities that become autonomous from the point of view of production also developing an approach to materialization of the goods of type reconstruction (repairing) and regenerative (refurbishing and remanufacturing).

22 Based on the thought of Ferber, the microproducers are considerable as "agents of production" which are intentional and modular cognitive models that allow them to realize their productive purposes consistently taking into account the constraints and opportunities offered by the presence and relationship with other microproducers.

23 Kühnle (2010, p.2):"…as the responsibilities for operations are strongly tied to organizational units and their socio-technical nature, Distributed (micro)Manufacturing also has all the features of human influenced-complex network building..."

Connectivity:	It develops interactions at all levels (material and immaterial, product and service, man-machine) also because the system tends to develop interacting and compatible base-components and technologies which make the processes and products evolve and innovate (Arthur, 2010).
Error-friendliness or resilience:	It can tolerate errors, omissions, or failures committed by the individual micro-producers without jeopardizing the overall functioning of the system.

The productive and business models of DM thus assume a recognized social role and value because they interpret the global culture and they valorise local skills and manpower, and because they assume a personal and human-centred dimension (Brown, 2013)[24].
In this sense microproduction has a value of social inclusiveness[25] (Benkler, 2006) and participative innovation[26], which has many points in common with social innovation and can be considered a driver of the socio-economic ecosystem's development.

In this regard, another important feature of DM concerns the integration between the demand for and supply of goods and services connected to manufacturing and which must be advantageous and desirable at several levels: economic, social, and environmental.
It is apparent from these conditions that microproduction is also a hybrid form of formal/informal social production, which is not solely oriented to profit; nor undertaken only by actors (enterprises) that base themselves on the traditional models of the division of labour; nor compliant with many of the traditional norms of commercial law.

This, therefore, is a set of manufacturing activities difficult to measure with the traditional socio-economic indicators[27]. Because they operate in a circuit of places, practices, tools and codified services, they can be formalized in a different manner.

1.4 Distributed Microprodution: places, processes, techniques and tools, technologies and machines

All examples of systemic innovation involve the creation of new products and services which incorporate new tools, technologies, and infrastructures that make the innovations available (Leadbeater, 2013). Many systems are largely based on the relation among machines; others are based only on people. But almost all of them combine human and technological elements (Mulgan, 2013). In Distributed Microproduction this relationship tents to be symbiotic (Fuller, 1970; Arthur,

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24 See the Guide to Social Innovation by the European Commission (p.22). http://s3platform.jrc.ec.europa.eu/documents/10157/47822/Guide%20to%20Social%20Innovation.pdf, last accessed: September, 25th, 2013), http://ec.europa.eu/regional_policy/sources/docgener/presenta/social_innovation/social_innovation_2013.pdf http://ec.europa.eu/enterprise/policies/innovation/files/social-innovation/strengthening-social-innovation_en.pdf Gasson, S., "Human-Centered Vs. User-Centered Approaches to Information System Design", The Journal of Information Technology Theory and Application (JITTA), 5:2, 2003, p.31-32

25 DM is also inclusive because has low form of access: it is quite easy to become self-producer, the DM can facilitate the participation of individuals previously excluded from work, can create forms of distributed production that enable small additions of income.

26 Tim Brown argues about participatory innovation referring to the social dimension of making: "… Rapid prototyping and "learning by making" is already an accepted strategy for effective innovation. For participatory systems, this is even more important because the complexity of the interactions cannot possibly be anticipated by even the smartest of plans. The reality is that these prototypes cannot live in the lab; they have to be let out into the wild. So, we need to start getting comfortable with letting others participate in our innovation activities. Of course this means that many of our accepted notions of IP and trade secrets go out of the window. This is very scary for the lawyers…" designthinking.ideo.com/?p=301

27 Currently the SME Department of the World Bank works with the following definitions: microenterprise- up to 10 employees, total assets of up to $10,000 and total annual sales of up to $100,000; small enterprise- up to 50 employees, total assets and total sales of up to $3 million.

2010)[28]. This change facilitates the search for new forms of direct participation in and personal control over production, and it shifts the focus of innovation from design of the system-product to design of the entire production-distribution system, so that production places, processes, techniques and technologies must be designed for an increasing number of microproducers.
Local fabrication is made simpler and more economical by the development of the miniaturized and low-cost productive technologies now available in consumer versions. The open design of hardware/software enables the self-construction of an increasing variety of the same (Open Source Tools and Multimachines, fig. 3)[29]. Finally, the new machines are flanked by an increasing number of under-utilized or non-utilized industrial machines, which suggest new ways to use individual units to large-scale industry actors. This gives rise to new enterprises dedicated to the recovery, hacking, or customization of these technologies.
To be emphasised is the ongoing social process of reappropriation of direct and personal control over the means of production. In substance, now emerging is a corpus of instruments and machines which (i) create an augmented craftsmanship so that it is possible to simulate, reproduce, and enhance craft techniques; (ii) recreate a simplified industry by reproducing entire industrial processes and plants in extremely miniaturized and manualized form (a sort of jugaad technology, fig.4)[30].

Fig. 3 – OSloom, the Open Source Loom, source: www.osloom.org
Fig. 4 – The Creative Factory developed by the designer Italy Ohaly is a concept of an industrial implant completed reduced and manualized, source: www.ohaly.com/

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28 Brian Arthur during says: "technology is becoming organic, nature is becoming technology". Ephemeralization is a term coined by R. Buckminster Fuller in 1922 describing the ability of technological advancement to do "more and more with less and less until eventually you can do everything with nothing". Fuller's vision was that ephemeralization will result in ever-increasing standards of living for an ever-growing population despite finite resources. The concept has been embraced by those who argue against Malthusian philosophy (http://en.wikipedia.org/wiki/Ephemeralization).

29 e.g. OS Loom (http://www.osloom.org/), OS Lathe (http://opensourceecology.org/wiki/Open_Source_Lathe), The Multimachine (http://opensourcemachine.org/), PocketNC (http://www.pocketnc.com/), Knitic (http://www.knitic.com/).

30 See Singh, S., Deep Sharma G., M. Mahendru (2011) "The Jugaad Technology (Indigenous Innovations). A Case Study of Indian Origin", in Asia Pacific Journal of Research in Business Management, Vol. 2, No. 4, April 2011

The general properties of DM systems also apply to individual production technologies (smaller, simple to use, easy to move and to link online in networks). They allow the granular diffusion of production by infrastructuring a network of real and virtual places, which recast the traditional models of MD organization.
The significance of places like ateliers, studios, workshops, and laboratories therefore changes to give way to production systems with a personal dimension (personal fabrication) or a collective one (community-based fabrication). And they can also generate a plurality of diversified and personal production processes where hand-made manufacture combines with digital fabrication, and even with biofabrication ('nature as a factory'). In this new technological landscape, we may distinguish three possible evolutionary scenarios for production sites: factories, labs and hubs, and platforms (Tab. 2 and Fig.s 5,6,7,8).

Tab. 2 – Production sites of Distributed Microproduction

(micro)factories2	Production units of small and extremely small size that adopt tools and technologies for additive and subtractive miniaturized, open and peer-to-peer manufacturing: nano-factories (factories-in-a-box), desktop factories (factories on a table) and micro-factories (factories in a room), but also mobile microfactories (kiosks and floating factories), temporary ones (pop-up factories), connective ones (plug-and-play factories) and educational microfactories (teaching factories).
Labs and Hubs (fablabs, makerspaces, hackerspaces, machineshops),	Public or private laboratories that offer services for on-demand and on-site production in urban neighbourhoods or districts. Similar places are developing in universities and schools, in do-it-yourself centres, or in public places like libraries or cafes equipped with technologies and machines (e.g. Garaget and Sewing Café).
Platforms	Platforms of services for personal fabrication, collaborative platforms for open design, open hardware or design-to-download, and platforms for microproduction (design-to-order and design-on-demand) directly integrated with distribution which, on the one hand, represent new 'markets of ideas', and on the other, make it possible to manage on-site or okm microproduction networks of designers, makers and craftspersons (e.g. Slowd, Fab.com).

DM can also be linked with other production activities now developing on the same logic: in fact, it also concerns prime materials, energy, and services for the distribution and marketing of products. In the field of the microproduction of prime materials, an increasing number of actors, like creatives or designers, are interesting themselves in the production of prime and semi-processed materials thanks to the development of new techniques, technologies and services of disassembly, deconstruction, recycling and re-use to create new materials (e.g. Sugru, Polyfloss, SeaChair Project)[31]. Products in glass, cement, plastic or individual hardware parts and components become the prime materials for the manufacture of new products, with indeed the creation of biological prime materials (e.g. BioCouture and The Chicken Project) or the microproduction of advanced materials (e.g. plastronics) thanks to the advent of DIY chemistry (e.g. openmaterials.org). In other cases, the production of prime materials is tied up to the diffusion of microplants for the production of cements, plastics, and metals (e.g. desktop foundries, mini-mills or DIY refractory ovens[32]).

Likewise, other creatives, designers and inventors critically and experimentally address the issue of integration between the microproduction and generation of energy to develop the greater energy independence of production systems, also ensuring its replicability in different contexts and with different energy conditions (e.g. Wind Knitting Factory, Solar Synter[33]).

31 sugru.com/ ; thepolyflossfactory.com; seachair.com
32 Personal Factory http.//personalfactory.eu is a small scale system composed by a mini plant (Origami) and a service which provide high-quality chemical kit, enabling the microproduction of tailored products at a fraction of the regular cost.
33 http://www.merelkarhof.nl/,

Fig. 5 – 3D printer Kiosk developed by Unfold Design Studio, unfold.be/
Fig. 6 – The Chicken Project Biofactory, http://kierenjones.com/
Fig. 7 – The Polyfloss microfactory, www.thepolyflossfactory.com/
Fig. 8 – The Wind Kitting Factory developed by the the designer Merel Karhof, (www.merelkarhof.nl)

In parallel, the reconfiguration of distributive channels comes about through new networks and platforms specialized in the global-scale marketing of micro and self-products. Microproducers thus have an increasing number of options: they can easily engage in their own e-commerce or use aggregator services for personal fabrication (e.g Ponoko, ponoko.com) or personal marketplaces for craft and handmade products (e.g Etsy, etsy.com). Moreover, traditional shops are converting themselves into centres for on-site production whereby the productive and distributive phases coincide (so that production becomes a core experience of the purchasing process). In parallel, new formats specialize in the marketing of the new micro-products (open design stores). As a whole, this set of resources, and the innovations that they produce, can be appraised as:

> "…an interconnected set of (micro)innovations, where each influences the other, with innovation both in the parts of the system and in the ways in which they interconnect…" (Freeman and Perez, 1982)

> "…Systemic social innovation occurs when a number of complementary innovations occur in a parallel and interconnected way to impact on a social issue or problem…" (Mulgan et al, 2012)

DM represents a significant part of a socio-technical paradigm emerging in a period of great socio-economic change (the current global crisis), and it engenders innovation by simultaneously operat-

ing on the diverse elements of a system. It produces new ideas and concepts in terms of product-service systems[34]; it changes the structure and metrics of the market; it fosters the development of open and peer-to-peer production technologies and their diffusion; it favours widespread changes in the behaviour of producers and consumers, in production structures and production and distribution processes; it generates new roles and new competences in existing actors; it also encourages the creation of alliances, communities and movements by modifying existing power relations (e.g. with industry or the distribution system).

2 Distributed Microproduction as systemic activity

With the development of the service economy, processes of servitization have progressively transformed products into product-service systems, and systems of industrial production into a Manufacturing Service Ecosystem[35] (Neely, Benedictine, and Visnjic, 2011). This eco-systemic dimension is observable in the field of MD (Vally, 2012), particularly in the development of 3D printing and personal fabrication, and in the FabLab Ecosystem (Troxler, 2010, 2012, 2013), which were born in the service economy and operate to enable distributed and democratized production. The main features that qualify MD as a socio-technical system are: systemic openness, widespread interactivity, community enabling, fractal organization, and social learning.

2.1 Systemic openness

In the social sciences, an open system is a process that exchanges material, energy, people, capital and information with its environment (interactional openness, Luhman, 2004). The growth of the open source movement[36] driven by its expansion from the world of software to that of design, data hardware, and materials is generating the conditions for the potential development of production chains and systems able to express systemic openness (e.g. Open Source Ecology). Although the link between the worlds of open source and distributed production has implications and problems much more complex than those of software (Troxler, 2013), DM today takes the form of a diffused laboratory (perhaps the most advanced one in existence) for real experimentation with forms of systemic openness. Apparent in the field of DM is the co-presence of developers, organizers, and users of openness who hybridize open innovation tools with the community-driven and collaborative development practices of open source to give centrality to design (Avital, 2012). Designer-producers indubitably represent a key cultural and operational element in the strategic use of openness. Since the first 'open design manifesto'[37] a growing community of designers-manufacturers-developers has incorporated the principles of open source into traditional design processes, thus offering closed and open versions of their products (e.g. Oskar Zieta, Design for Download, Droog Design)[38]. Others instead develop ex novo entire systems and platforms, which enable open design by working on the development of new rules and standards (e.g. Wikihouse and Open Desk, Open Structure, fig.9)[39]. These platforms complete the current range of those for open hardware and open production (e.g. Instructables.com). They thus make it possible for a growing number of micro and self-producers to draw on a system of open resources, which enables them to plug gaps in technol-

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34 Report of the European Commission on Systemic Innovation (p.5): "…Even though many of these elements will be common to all types of innovation, or could themselves be examples of social innovations, we argue that systemic innovation will require many of these elements to be in place to be truly transformational. These elements includes: Developing following a crisis or period of upheaval, New ideas, concepts and paradigms, Coalitions for change of many actors and/or across more than one sector or scale, Changed power relationships and new types of power structures, Widespread diffusion of technology and technology development, New skills or roles across many actors, New institutions, Widespread changes in behaviour, structures and/or processes…"

35 See T.S. Baines, H.W. Lightfoot, O. Benedettini, J.M. Kay, (2009) The servitization of manufacturing: A review of literature and reflection on future challenges, Journal of Manufacturing Technology Management, Vol. 20, pp.547 – 567.

36 Samples of ecosystem of openness: Open Hardware Project, Open Design Group at Open Knowledge Foundation, Open Source Hardware and Design Alliance, Open Source Hardware User Group, Open Knowledge Foundation, Open Hardware Freedom Defined, Open Hardware Association, Open Materials, Open Hardware Catalogue. Many other samples are mentioned on the website of P2P Foundation (http://p2pfoundation.net/Product_Hacking) and Massimo Menichinelli Blog's OpenP2PDesign (http://www.openp2pdesign.org/2011/open-design/business-models-for-open-hardware/).

37 The concept of open design has been developed in 2004-2005 by the designer Ronan Kadushin with his Thesis, http://www.ronen-kadushin.com/files/4613/4530/1263/Open_Design_Manifesto-Ronen_Kadushin_.pdf

38 http://studio.droog.com/studio/all/design-for-download/

39 www.opendesk.cc, www.wikihouse.cc, openstructures.net/

ogy or design so that they can complete their production. Finally, openness is becoming terrain for cooperation between the world of DM and traditional manufacturing industry. An increasing number of medium-sized and large firms or firms' associations are developing pilot projects centred on open innovation which promote (e.g. Natevo) or 'use' micro and self-production to test new uses and applications of their technologies, and to develop new product and process concepts.

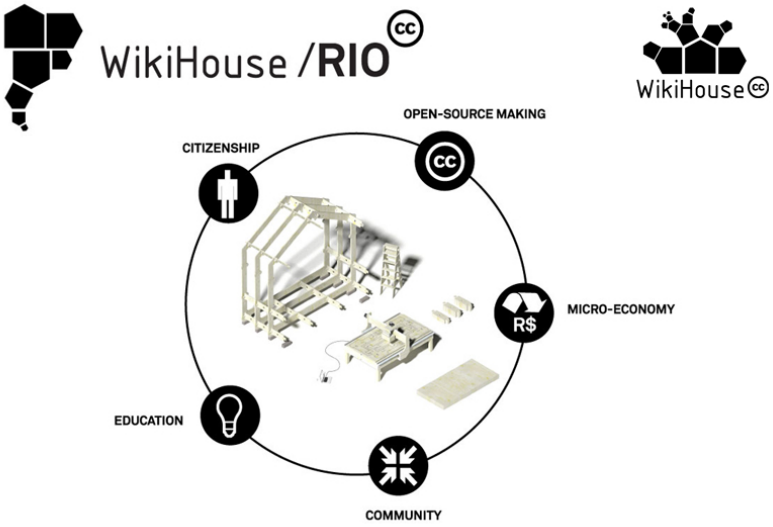

Fig. 9 – The Concept of Open and Distributed Manufacturing of Wikihouse, an a perfect sample of fractal organization, www.wikihouse.cc/

2.2 Widespread Interactivity

In systems theory, an emergent property appears when a number of simple entities (i.e. makers) operating in a particular environment (i.e. a fablab) generate more complex behaviours as a collectivity (Buchanan, 2003).

The prime condition for the development of DM is that a certain number of microproducers be able to stabilize themselves by interacting with each other (exchanging knowledge, materials, products, techniques and technologies), thus reciprocally influencing their behaviours and productive performances. It is only through constant interaction among the microproducers that this system acquires new behaviour and is able to innovate.

Fostering the development of DM systems therefore requires acting, not on the individual microproducers, but on the tools, devices, and services that encourage their interaction in design (from tinkering to things, as in the case of makerspaces), in learning of uses between microproducers and machines (from bits to atoms, as in the case of fabbing or rapid manufacturing), processes of collective cognitive interaction (from codes to products, as in the case of open design, or generative design); and from frames to things, as in the case of video tutorials on 'how to make'.[40] The increasing possibilities to combine these types of interaction[41] promote the development of new planning-production-distribution processes exemplified by new kinds of interface such as design apps, interactive fabrication[42] (gestural and interactive sculpting, spatial sketching), and haptic technologies (haptic, tangible, embedded and embodied interfaces, fig. 10, 11)[43].

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40 e.g. CraftTuts+ http://craft.tutsplus.com/, the section "projects" of the Make Magazine website.

41 We refer to processes of connection, aggregation, sharing, and exchange that may include: information and knowledge related to the design, practices and production techniques, technologies and equipment, the use of facilities.

42 Gestural sculpting, interactive sculpting, spatial sketching. See http://www.interactivefabrication.com/ (last accessed: September 25th, 2013).

43 Samples: Computer Augmented Craft, 3D Printing Pen, Artisan electronique, Haptic Intelligentia, Constructables Interactive Lasercutting.

Fig. 10 – Computer Augmented Craft, http://christianfiebig.de/computeraugmentedcrafts/
Fig. 11 – L'artisan Electronique, unfold.be

2.3 Community enabling: (micro) networks and alliances

For a system to be truly be innovative, it must be able to build alliances (Leadbeater, 2013). In the DM system, this property translates into a large number of microproducers who develop Community Based Fabrication projects (e.g. Fab@home, RepRap, fig.11) also by devising models of Community Supported Manufacturing[44] where the production sites – digital fabrication plants – are co-financed or co-managed by a number of actors interested in the development of particular products, whether individual or collective (hackerspaces). These models of microproduction seek to enable, use, and enhance local skills and work practices by linking them with those present on global platforms[45].

44 See the P2Pfoundation Website by Michael Bawens (http://p2pfoundation.net/Community_Supported_Manufacturing)

45 Three different types of networks are developing in the field of DM. The first concerns the platforms that create networks among dispersed and unconnected productive resources to generate online services for personal fabrication (e.g. CloudFab, MakerMap). The second type concerns virtual platforms developed by the producers of open-source technologies and service aggregators for digital manufacturing with the objective of networking on a global scale the microproducers to which the technologies are furnished (MakerBot Industries with the concept of BotFarm, 100kGarages with ShopBot). The third concerns the network of makerspaces comprising networks of individuals who adhere to a precise "format" (Fablab or TechShop) and those which link independent spaces pertaining to communities of practice like local hackerspaces (Mota, 2011).

The concept of community of practice (Himanen, 2003; Wenger, 1998) is therefore well visible also in the activities of urban microproducers, and also of independent microproduction distributors which create local associations and alliances scalable and extendible to the national and global level: SFmade with Urban Manufacturing Alliance[46], Open Craft Italia[47]. Even subjects such as Designer = Enterprises organize groups or networks (e.g. C-Fabriek,[48] The Machine, and Produzione Impropria, fig.12[49]) in order to promote themselves a new vision and culture of micro-production.

These initiatives undertaken by diverse types of microproducers exhibit recurrent and common dynamics and patterns, which consolidate a microproduction community through creating or frequenting a place or productive initiative, or through a dispersed set of experiences. The convergence of these actors on the basis of shared interests shapes the experience or the community with toolkits[50], standards, wiki,[51] certifications, and licences, which formalize their principles and rules and make participation-reproduction-replication-reiteration possible through mechanisms of enrolment and affiliation. These community models comprising instruments for self-assessment and peer-review are indicative of the fact that there are legislative gaps in regard to open design, micro and self-production that may favour the creation of alliances for controversial productive purposes (e.g. Distributed Defense[52]).

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46 The Urban Manufacturing Alliance (UMA, www. http://urbanmfg.org) is a national collaborative of non-profit, for-profit and governmental stakeholders across major US cities, working together to grow manufacturing businesses, create living wage jobs and catalyze sustainable localized economies.

47 Opencraft.it is an aggregator of Italian start-ups who promote and sell unique products and self-production Made in Italy

48 Since 2011, several events have been organized bringing together the work of Designer = Enterprise. Among the main ones: (2011, Berlin); (2012-2013, the-machine.be/en); (2012, c-fabriek.nl); (2012, Amsterdam); (2012, Milan); (2013, Milan, www.invisible-design.it/), and at Milan Design Week (2013, Milan,), (2013, London, the-future-is-here.com/topic/all/), (2011 e 2012, Torino, http://operae.biz/), (2010-2013, various Italian cities, http://opendesignitalia.net).

49 Produzione Impropria (http://produzioneimpropria.com/). Produzione Impropria is a collective of designers created spontaneously from the projects developed by the Autoproduzioni Lab (Stefano Maffei, Barbara Parini, and Massimo Bianchini, School of Design, Polytechnic of Milan). Currently some of the projects have been selected in international fairs and exhibitions (e.g. at Europe Maker Faire and on Make Magazine). See more in Alessi, C. (2013). Produzione Impropria. In , 633.

50 UMA Toolkits are practical guides focused on sharing best practices from multiple UMA cities, with a focus on implementation. From workforce development to local branding to land use and zoning, UMA Toolkits cover the specific challenges and solutions that are working now to help grow and support the local manufacturing sector in our cities. “Urban Manufacturing Alliance Toolkit: How to Develop a Locally-Made Brand Platform” http://urbanmfg.org/wp-content/uploads/2013/05/UMA-Local-Branding-Toolkit-Final1.pdf, (http://wiki.fablab.is/wiki/Main_Page)

51 (http://wiki.fablab.is/wiki/Main_Page)

52 Defense Distributed (http://defdist.org/) is an association of open source weapons makers which aims to develop and publish freely the design of weapons that can be downloaded and reproduced by anyone using a 3D printer.

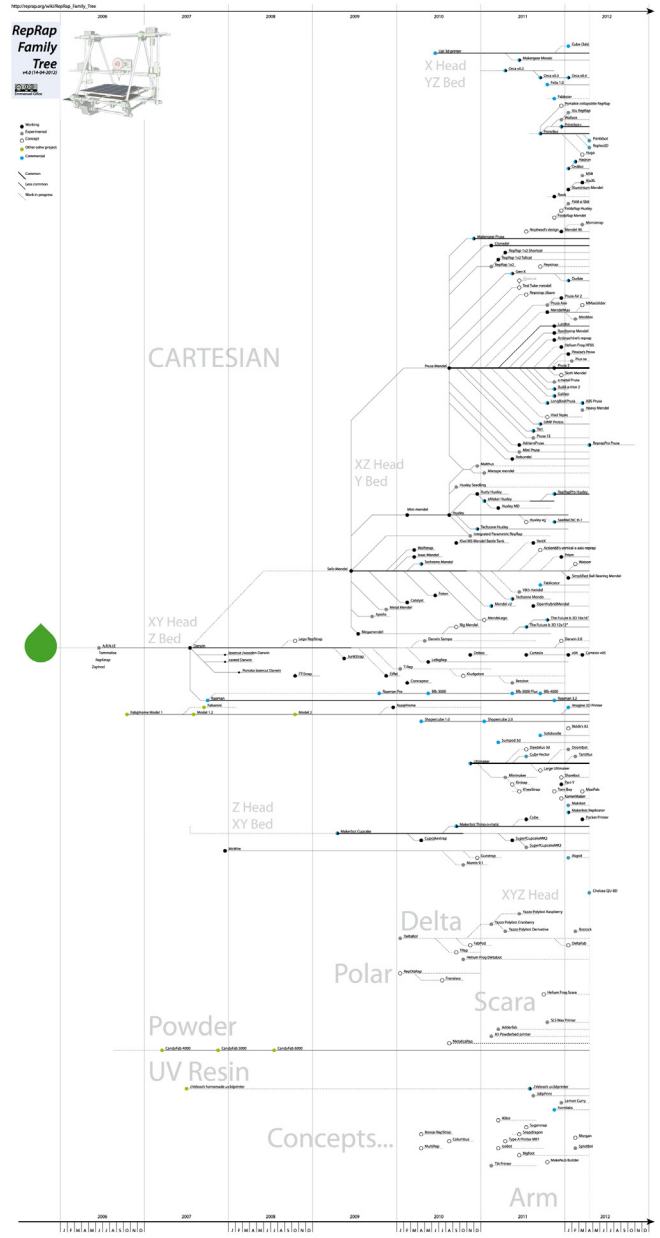

Fig. 11 – The RepRap Family Tree shows the fast 'social development" of RepRap 3D printers during the period 2006-2012, http://reprap.org/wiki/RepRap_Family_Tree
Fig. 12 – MusicInk is a project spawned from the idea of looking into the world of music teaching, creating a new way to understand music and interact with musical instruments for schools and children, http://musicink.co/

2.4 Fractal organization

Fractal Organizations have flat hierarchies, and they distribute tasks and responsibilities (Hoverstadt, 2009). Likewise transformed in the DM system are certain hierarchical models consolidated in manufacturing industry: for instance, the relationship between the producers of final goods and sub-suppliers (cars, prime materials, and components). In this emergent system, the microproducers and the producers/suppliers of technologies are substantially equal; the difference is that the producers of technologies, like MakerBot and Arduino, are the new micromultinationals of microproduction (the equivalent of Microsoft for the traditional industrial system).
Evident in some components of the DM system are features and behaviours that pertain to fractal organizations (Warnecke, 1997). The first of them is self-similarity: microproducers tend to develop automorphic processes: that is, as they grow or transform, they tend to preserve all their organizational, structural and constitutive characteristics. The organizational model of the fablab is growing exponentially[53] precisely by adopting a cellular-network process. Every fablab, in fact, maintains its original model unchanged by not growing in size but by replicating and connecting itself. The scale-up of the DM model therefore comes about, not because of growth in size or economic performance, but because of the increased granularity of activities. This ensures the self-organized flexibility of small production volumes by individual micro-producers, but also makes possible large volumes produced by the system as a whole (in that it is potentially able to activate, steer and coordinate communities of microproducers by distributing production volumes). This systemic adaptability of DM requires a mix of leadership styles (Leadbeater, 2013), which are personal (Bianchini and Maffei; 2013) but are made collective by temporary processes of delegation. Moreover, the DM system is redundant: there is no functional separation-specialization among its parts: indeed, all the microproducers are potentially able to develop any organized part of the DM.

2.5 Social learning

In DM, the convergence and simultaneity among practices of learning by doing, by using (Rosenberg, 1982; Arthur, 2010), and by interacting (Lundvall, 1994) made possible by the network, by collective activity, and by multiplication of the personal experiences of the microproducers generate norms and behaviours that take the form of a social system. The logic that drives them is peer-to-peer, and it is manifest in processes of social learning centred, in these early stages of development, on copying and emulation. The key aspect concerns the reconstitution of an idea of creativity which, in a DM system, is cultivated through numerous types of intelligence (and of diffused knowledge) and personalized educational paths (Robinson, 2010), and in which 'tinkering' is essential for innovation (Brown, 2011).[54] Identifiable in the DM system are two core components of learning: the relation between tacit and explicit processes, and the relation between individual/personal and social/collective processes. On the one hand, microproducers tend to concentrate into an individual cognitive capacity a set of professional skills previously distributed among several actors. These are learning processes that enhance the capacity to self-visualize all the aspects of design, production, and distribution it is the prerogative (Bianchini and Maffei, 2013). On the other, testifying to the importance of explicit knowledge diffusion and acquisition processes in DM is the increasing number of platforms, like Instructables, I-fix-it, and Craft-Tuts, which codify or generate knowledge and information on what and how to produce individually (DIY) or collectively (DIT), and which fuel processes of learning by copying or emulation. All this means that the traditional models of ritualized and initiatory learning typical of crafts (Sennett, Micelli, 2011; Adamson 2013) are gradually integrated with different training models: ones that are more social, open and centred on tinkering (e.g. the iTinker School), and informal (e.g. the Etsy Hacker School). This co-presence of different learning models is apparent in many makerspaces in which programmes are dedicated to 'how-to-make' training (e.g. Fab Academy, Betahaus) or in places (e.g. Artisan's Asylum, Techshop) where training methods have close similarities to those of vocational education.

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53 In a recent interview at MAXXI Museum in Roma, Neil Gershenfeld said that the number of FabLabs doubles every 18 months (essentially following Moore's Law on the development of microprocessors).

54 Some training organizations have realized this possibility and developed programs that codify and transmit knowledge for D=Es. Kaos Pilot is a study course focused on personal development, value-based entrepreneurship, creativity, and social innovation; John Thackara's xSchool gives designers practical skills with which to help their enterprises and institutions become more sustainable; the Tinkering School teaches children to become competent through forms of learning-by-doing tied to the physical and experimental dimension of making.

3 Microproduction Everywhere

An emergent system like DM may arise spontaneously from decentralized settings. But in order to consolidate, it must possess a certain combination of diversity, organization and connectivity. Although numerous microproductions, especially the more innovative ones, have all these features and are logical from the environmental, economic and social points of view, in reality they are not yet able to produce real, significant, and measurable change within the contexts in which they operate. The essential and binding condition for the development of the DM system is that it must integrate with a more complex ecosystem, such as the urban one where the core of production today consists of services. Behind development of DM there therefore lies the idea that it is possible to imagine the existence of an ecology of production whose engine is constituted by a system of material and immaterial microproduction that also comprises the services dimension with a view to social and ecosystemic innovation:

> "…An innovation ecosystem is a non hierarchical form of collaboration, in the past mostly founded on a territorial proximity like Smart Regions or Districts but nowadays extending globally worldwide, where big OEMs (original equipment manufacturer), SMEs networks, ICT suppliers, universities and research centers, local public authorities, individual consultants, customers and citizens work together for promoting and developing new ideas, new products, (new services), new processes, new markets…" A definition by COIN projects [*www.coin-ip.eu*]

Contemporary cities could therefore be animated by DM micro-networks and micro-chains integrated with the metabolism (energy, materials, commodities) of an urban ecosystem; and they could produce new material cultures starting from the intelligent use of the territorial capital of resources and skills considered from a bioregional perspective (McGinnis, 1999). The relation between the DM system and the urban ecosystem with its manifold services determines the conditions for the local development of a productive ecosystem that we term Microproduction Everywhere (ME) able to generate a dynamic alignment between the local demand for and supply of products and productive capacity (also of services)[55].
From an ecology of production standpoint, this balancing may produce positive impacts on work processes, and on the production-use of energy and prime materials, while at the same time satisfying the need for products-services in terms of quantity and quality (fig.13 and 14).
In short, Microproduction Everywhere, through access to and distributed control over the means and scale of production, may generate new processes of productive sense-making.
ME may render also services more efficient and sustainable by enabling processes of micro- and self-production in this field, thus stimulating the development of services characterized by self-management models.

55 Possible fields of application of Microproduction Everywhere in relation to the world of services are the following: urban farming, growing and community-supported agriculture (in terms of equipment); education and culture (in terms of technical equipment for schools and museums); mobility and transportation (in terms of customization and regeneration of vehicles, bicycles); healthcare (in terms of technical equipment and prostheses); security (in terms of drones and other equipment for monitoring and surveillance); on-site production services (for the self-production of goods, the repair, regeneration and remanufacturing of products).

Fig. 13 and 14 – The fablab Amsterdam at Waag Society Institute represent one the best samples of convergences between making and social innovation topics, e.g. The http://fablab.waag.org/project/fab-prosthetics

All this has a final implication: the possibility that ME may also be place-making[56] or urban-regenerative[57]. The processes of (industrial) civilization have shaped our life environments. During classic industrialization processes, the installation of production contributed to structuring both the physical and social-cognitive environment. In the DM field, this aspect is reversed: it is urban contexts emptied of industrial production that shape or define DM when it is relocated and distributed in the urban ecosystem on the basis of how the environment is made up and the possibilities/forms of installation that it offers. ME is therefore an ecosystem structured by the city because its generative part is constrained by the existing ecosystem in a process of co-evolution and co-innovation. The DM is a universe of personal and social making (Gauntlett, 2011) that can support the materialization process of social innovation.[58] In few words: microproducers are crafting, equipping, fabbing, and making social innovation.

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56 Placemaking is a multi-faceted approach to the planning, design and management of public spaces. Placemaking capitalizes on a local community's assets, inspiration, and potential, ultimately creating good public spaces that promote people's health, happiness, and well being. Placemaking is both a process and a philosophy.

57 Zoning is one of the major problems with regard to the Small Urban Manufacturers (source: Pratt Report on Small Urban Manufacturing and posters of the associations of local producers).

58 "… Social innovations can be understood as new solutions (products, services, models, markets, process es etc.) that simultaneously meet a social need (more efficiently and effectively than existing solutions) and lead to new or improved capabilities, assets and/or relationships.", http://ec.europa.eu/enterprise/policies/innovation/files/social-innovation/systemic-innovation-report_en.pdf.

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Footnotes

1 The concept of spime developed by Bruce Sterling in his Shaping things (2005) is appropriated. The main technologies of spimes are related to identification (e.g. RFID), geolocalisation (e.g. GPS), searching data, (e.g. Internet Search Engines), creation (e.g. CAD), and fabrication (e.g. 3D printing).

2 The original definition of microfactory refers to a small dimension factory able to produce small dimension. The term was proposed by the Mechanical Engineer Laboratory (MEL) of Japan in 1990. See in Okazaki Y., Mishima N., Ashida K. (2004) Microfactory — Concept, History, and Developments, in Journal of Manufacturing Science and Engineering, pp. 837–844.