Facing the transition: Visions around Industry 4.0 from makers and manufacturers

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ABSTRACT: The transition towards a digitized industry is full of challenges and perils, as well as it encompasses many business opportunities for the renovation of the European manufacturing sector and the safeguarding of its competitiveness at international markets. Development of a more service-oriented strategy, digitization of entire value chains and introduction of new disruptive technologies in production plants such as IoT, AI, robotics or 3d printing have been commonly argued as imperious needs by the European policy arena. This demand for the development of an Industry 4.0 paradigm in the old continent has also been backed up by significant initiatives such as the "Factories of the Future" Public Private Partnership by the EC as well as other important coordinated efforts at national level by member states.

However, this transition towards an automated, connected and smart factory is full of uncertainties, as different concerns regarding unemployment and deskilling, asymmetries between regions, labor rights at stake, social welfare, massive surveillance or alienation are increasingly emerging. These worries are also rising different demands for favoring sustainable and responsible approaches to industry digitization that can consider socio-ethical aspects of innovation, and meeting at the same time, the pressing challenges that are at the forefront of new development agendas like the Sustainable Development Goals promoted by the United Nations.

In contrast, other alternative forms of engagement with these disruptive technologies associated with the next industrial revolution are emerging in alternative spaces that don´t respond to the logic of central control, high hierarchy and Taylorism that can be found on classical production facilities. Makerspaces, fab labs and hackerspaces are also promoting the social diffusion of these technologies but with very different aims, goals and values. In this sense, worldwide trends like open design, FLOSS, open hardware and open manufacturing are acting as facilitators of these technologies in grassroot innovation communities, providing alternative paths of technological development outside the ones that are present in traditional R&D ecosystems. Thanks to these urban labs, social appropriation of these technologies is promoted throughout informal and non-formal learning ecosystems, as well as commons-based peer production and participatory approaches are commonly facilitated.

In this contribution, visions about the factory of the future and the road to Industry 4.0 paradigm are explored in two different communities that are affected by these technologies: makers and manufacturers. Empirical evidence gathered throughout 80 semi-structured interviews carried out in the OPENMAKER[1] project is exposed, discussed and contested to shed some light on the different motivations that lead these individuals to be engaged around innovation. In the text, I stress the potential of these communities of grassroots innovators to outline alternative R&D paths oriented to societal needs and challenges, providing democratic and sustainable technological development regimes. The idea of post-automation is also put into context for exploring how it can contribute to develop innovation policies that can be legitimated by citizenship and oriented to societal demands that are pulsated by urban labs.

KEYWORDS: P2P, digitalization, maker culture, DIY, post-automation.

[1] OPENMAKER is a European project funded by the EC under Horizon 2020 framework programme. See https://openmaker.eu/

1- Introduction

As we are facing a transition to a post-industrial economy, where the role of education, technology and work itself will be reshaped by new technologies, expectations and uncertainties about this transformation are starting to emerge in different communities affected by. The aim of this contribution is to shed some light on how Industry 4.0 is perceived by two communities of innovators: makers and manufacturers.

2- The imperative of Industry 4.0

During the last decade, a new technological revolution has gained momentum in the European policy sphere. With the aim of providing an industrial renaissance that can spur jobs, investments and business opportunities after the economical backlash provoked by the crisis, this new mantra of economic development has adopted the shape of "Industry 4.0" paradigm (Smit, Kreutzer, Moeller, & Carlberg, 2016). The term was originally conceived at Hannover Messe (industrial fair at Germany), as a marketing innovation for powering the positioning of the Teutonic industry and confronting at the same time the growing competition overseas. Broadly speaking, Industry 4.0 encompasses "*a group of rapid transformations in the design, manufacture, operation and service of manufacturing systems and products*" (p2, Davies, 2015).

The main advances of this new paradigm lie in the possibilities that the digitization of physical world and value chains can bring into the manufacturing business. Decentralized decision making, connectivity in real time, collaboration between humans and machines, development of new services associated to industrial products, as well as the merger of machinery and digital systems are some of the most common arguments for this plea (Davies, 2015; Smit et al., 2016). These advancements lie in the introduction of new disruptive and automating technologies into the factory such as Internet of things (IoT), artificial intelligence (AI), 3D printing, robotics, digital twins and many others. These are also behind flagship initiatives promoted by the EC, such as the "Factories of the Future" Public Private Partnership, as well as the coordination of national and international strategies oriented to promote technological upgrading and investment in Industry 4.0[2]. The quest for pursuing this technological paradigm has becoming an "innovation imperative", as this socio-technical imaginary is perceived as a desired digital future for Europe (Jasanoff & Kim, 2013; Pfotenhauer & Jasanoff, 2017). An awaited scenario that is expected to guarantee the competitiveness of European industry at international level and providing to European society at the same time, with jobs, economic growth, business opportunities and a significant contribution to the maintenance and extension of welfare state.

However, this transition is full of challenges and uncertainties, as several stakeholders outside this paradigm have shown little awareness about it (Smit et al., 2016). This has favored the projection of some spectral shadows about future unemployment, workforce deskilling, massive workplace surveillance, labor rights struggling, technological alienation, welfare state sustainability or inequalities and asymmetries between industrialized European regions (Fuchs, 2018; Gutiérrez & Ezponda, 2019). These emerging worries that are around this socio-technical imaginary have also stressed the need of favoring a sustainable and responsible approach that can meet societal expectations, as well as including socio-ethical aspects of innovation in technological roadmaps (Stilgoe, Owen, & Macnaghten, 2013). In this sense, new approaches to innovation policies for meeting the objectives of the Sustainable Development Goals (SDG´s) developed by UN are gaining importance in this matter, in the form of transformative innovation policy (Schot & Steinmueller, 2018).

In addition, some alternatives form of engagement with disruptive technologies that have been recently popularized throughout fab labs, hackerspaces and makerspaces (from now on makerspaces) can help to point out some alternative directions in this matter. These grassroots innovation movements are promoting the social diffusion and appropriation of technologies that

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[2] See for instance https://ec.europa.eu/digital-single-market/en/blog/factories-40-future-european-manufacturing

are at the core of Industry 4.0 such as 3d printing, IoT and AI, but with very different aims, goals and values (Smith, Fressoli, Abrol, Arond, & Ely, 2017). They rely in a different ethos that has been inherited by other previous movements of technological emancipation such as DIY philosophy, P2P practices, hacker culture or FLOSS, as well as other contemporary major trends such as open design, open hardware and open manufacturing (Maxigas, 2012; Niaros, Kostakis, & Drechsler, 2017; Tabarés-Gutiérrez, 2016). All of this have helped to these communities to explore alternative paths of technological development outside the traditional ones of R&D ecosystems. In this sense, innovative projects such as Fairphone, Aquapioneers, Wikihouse, DF Robot, Peeble, Arduino or Prusa are some of the examples that have showed that alternatives to the classical itineraries of R&D are possible, and maybe desirable (Gutiérrez, 2019).

In contrast to other kind of spaces such as incubators or accelerators, makerspaces and other digital fabrication labs promote a kind of engagement with new disruptive technologies oriented to social diffusion and social appropriation. These labs usually rely on informal and non-formal learning ecosystems, as well as participatory approaches that usually lead to a commons-based peer production regime (Benkler, 2006). These spaces can be also considered such as knowledge infrastructures as they usually are intertwined with a collection of digital infrastructures, communities of practice and a network of individuals that gather a significant pool of talent, tools, resources and know-how.

Makerspaces are also places for conceiving innovative projects that have different drivers that don´t respond to the classical economic logic, where maker entrepreneurs are motivated by other aims such as hedonism, social good, sustainability or social capital (Halbinger, 2018; von Hippel, 2017; Wolf & Troxler, 2016). These spaces do not also respond to the classical paradigm of mass production, where central control, high hierarchy and Taylorism is omnipresent and reduces the autonomy and agency of individuals. In this sense, makerspaces constitute post-automation alternative industrial settings, where individuals are subverting technologies that are pushing the Industry 4.0 paradigm with other aims such promoting individual and collective creativity, life-long learning skills, sustainable production, circular economy and others. In this sense, makerspaces are places to learn about change, to test and to experiment with other approaches that contest the classical dynamics, drivers and logic of innovation.

3- Methodology

To explore the current visions that can be found in making and manufacturing about the transition to the factory of the future, empirical evidence gathered throughout 80 semi-structured interviews carried out thanks to the OPENMAKER[3] project is analyzed. This initiative enabled funded partnerships between makers and manufacturers and involved participants into a collective acceleration period of 9 months. Projects included topics like 3D printing, robotics, AI, circular economy, waste recycling and others, that were mainly supported through 4 nodes (Italy, Slovakia, Spain and UK). These collaborations delivered substantial insights about motivations and values that can be found in the two communities about innovation, open source technologies and industry digitization.

From March 2017 to November 2018, 80 semi-structured interviews were carried out to three kinds of key informants: makers, manufacturers and stakeholders. The first kind of interviewee was people actively engaged in the maker movement such as fab lab managers, maker entrepreneurs or hackers interested in the development of open source technologies. Second group was composed by professionals from manufacturing that are interested in industry digitization and the introduction of open source technologies at factories. The last group is more heterogeneous as it comprises different individuals interested in the opportunities that maker culture can open up for innovation, entrepreneurship and manufacturing (innovation agencies, policy-makers, educators and researchers mainly).

The interviews have been delivered following a pre-designed script made by the project team, including questions regarding the use of open source technologies, involvement in collaborative

[3] European project funded by the EC under Horizon 2020 framework programme (https://openmaker.eu/)

projects, attitudes to openness and sounding out the participants about their perspectives towards Industry 4.0. The project team has also tried to maintain a good geographical balance between the aforementioned countries (IT, SK, SP, UK). Interviews length has been between 30 minutes from 1 hour and all the participants have received and Informed Consent Form (ICF) for understanding project objectives, data collection and data treatment processes. All interviews have been carried out face to face, when possible, or by video/telephone calls when not. Interviews have been recorded and main findings have been transcribed.

4- Expectations and motivations

The fieldwork carried out during the OPENMAKER project lifespan depicted several insights about how the different communities face the transition towards the digitization of European industry. Generally speaking, makers and manufacturers have different motivations and drivers to be engaged in innovation and they perceived the transition towards Industry 4.0 in different ways. The majority of makers interviewed were led by aims oriented to produce social good or positive social impacts throughout their projects, whilst manufacturers perceived innovation as a tool or a mechanism that allow them to survive in an increasing competitive market. It is also essential to point out that manufacturers that were involved in the study belonged in a majority to SMES (with some exceptions), with fewer resources than bigger companies to adequately deploy innovation.

In this sense, most makers also stressed the role of digital platforms as powerful tools for accessing new knowledge, materials and step-by-step guides that can be useful for promoting self-discovery, self-empowerment, knowledge sharing, creativity and engagement with new technologies. This was commonly argued to emphasize how platforms such as Github, Hackster, Wikifactory, Thingiverse or even Youtube and Instagram play an important role in knowledge generation for downloading designs, tutorials, photos, videos and many kinds of materials that facilitate the development of different prototypes and artifacts that can be built up in a makerspace. These tools that facilitate a “learning by doing” approach in emerging fields like digital fabrication, 3D Design or IoT was seen by many makers as a form to promote creativity in industry and as a source of collaborative innovation.

In relation to this, many stakeholders such as educators or teachers from high schools or vocational training organizations commonly refer to makerspaces and maker practices as a kind of bridge to meet the gap between classical educational activities and the current needs of companies, more oriented to competences and abilities. Some of the stakeholders were heavily involved in maker culture and they might be considered as makers, as they have contributed in their organizations to set up institutional makerspaces. However, their focus is in educational activities as they perceive the maker culture as a tool to facilitate new interactive and participative approaches to emerging technologies. The majority of the educators involved in the research considered that the Industry 4.0 paradigm is bringing in a significant leap forward in the way that manufacturing companies work and interact with its context. They also stress how new jobs will be developed in coming years aligned with the introduction of these technologies in factories, as well as the need of SMEs to embrace other innovation communities for remaining competitive.

In contrast, manufacturers involved at research usually stare at Industry 4.0 with a bit of reluctance, as they see this paradigm too pompous in some ways and maybe a bit out of their range of action. As it has been previously explained, the majority of companies involved in the research were SME´s, with fewer resources than bigger companies regarding innovation management and investment capacities. However, they usually acknowledged the advantages that automatization can bring into their production processes for making quality products and improving their efficiency and environmental sustainability. Some of them also pointed out digitization as a way to incorporate talent to their organizations, but at the same time they argued about the difficulty of this process and its high cost.

Last, bigger companies involved in the research perceived Industry 4.0 as a necessary transition where heavy investments are needed not only in machinery, but also in personnel and organizational culture, as the interconnection of different departments and processes throughout

digital technologies will demand new ways of working and the development of new business models. They also argued about possible tensions and conflicts between corporate departments, but they also envisioned opportunities from these interconnections and reorganizational processes towards a more problem-solving oriented structure.

5- Alternative paths and openings for a different kind of transition

As it has been shown in previous section, makers and manufacturers have considerable differences in their attitudes and motivations around innovation and Industry 4.0. This fact can be partially explained by the remoteness of these two groups in society, but also by their educational backgrounds and their different drivers to innovate (Halbinger, 2018; von Hippel, 2017). Traditional manufacturing, especially in SME´s, is still far from advanced manufacturing and this new wave of digital technologies is starting to question some of the already established modes of production that were developed in the last century, intimately associated with previous mechanical technologies.

Despite it is still early on to speak about a disruptive digital transformation or a technological revolution, it can be observed that this socio-technological imaginary that has been projected in Europe by different stakeholders is already permeating in several domains around manufacturing. This allows to observe how different communities position themselves around this topic and how they envision opportunities and challenges that this new industrial paradigm can bring into society. Here, it emerges the relative disparity of the ICT and manufacturing communities. In this sense, most makers see the transition as an opportunity to promote alternative values into the new kind of industry that is emerging such as creativity, collaboration, decentralization and sustainability, while most manufacturers stare at industry digitization as a possible threat to their current businesses and their associated practices.

However, grassroots innovation facilitated by makerspaces can confer new meanings to fabrication and introducing new values on it (Gutiérrez, 2019). Democratic and sustainable approaches developed in these labs can help to engage citizenship with manufacturing again, as well as promoting the social diffusion and appropriation of the technologies that will be used in this new kind of manufacturing (Smith et al., 2017). But most important, introducing into the Industry 4.0 paradigm a human-driven approach that has completely deterred in previous technological revolutions. Peer to peer practices and values behind maker culture can facilitate organizational learning, community building, as well as reinvigorating the autonomy of people in factories. It is necessary to stress that the factory is still the place where the class-struggle happens, and where historically, hierarchical means of control are used in detriment of the individual agency of individuals. If Industry 4.0 paradigm is not able to take a human-driven approach, it can be envisioned that humans as such, will be completely pushed of factories in the next digital transformation and with them, the social fabric that is meshed on it.

Last, innovation policies can be also benefited from the way that these communities are approaching to Industry 4.0 paradigm, with different drivers, aims and values to the ones that can be found in traditional conceptions of R&D (Halbinger, 2018; von Hippel, 2017). In this sense, transformative innovation policy can identify different openings that these post-automation settings are posing for industry digitization (Schot & Steinmueller, 2018). An emphasis in values such as creativity, collaboration, openness, sharing, sustainability or transparency can facilitate more ambitious policies oriented to great social challenges such as climate change or sustainable production and consumption. At least, open source projects that are being developed in these communities are underlining the feasibility of alternative R&D paths not guided by classical market incentives nor techno-solutionism approaches.

6- Conclusions

As it has been discussed in the text, makers and manufacturers have different expectations about Industry 4.0 paradigm. While the first ones see this transition as an opportunity for introducing new values and behaviors into the industry, the latter ones see this transition with some reluctance and doubts. Industry digitization can provide openings for transferring some of the

values of grassroots innovation communities to the manufacturing sector, but this will need significant policy tools and mechanisms, as these two communities are really far from each other.

Bibliography

Benkler, Y. (2006). *The Wealth of Networks: How Social Production Transforms Markets and Freedom*. New Haven and London: Yale University Press.

Davies, R. (2015). *Industry 4.0 Digitalisation for productivity and growth*. Retrieved from http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/568337/EPRS_BRI(2015)568337_EN.pdf

Fuchs, C. (2018). Industry 4 . 0: The Digital German Ideology. *Triple C: Communication, Capitalism & Critique*, *16*(1), 280–289.

Gutiérrez, R. T. (2019). La fabricación abierta : ¿un camino alternativo a la industria 4.0? *Revista Iberoamericana de Ciencia, Tecnología y Sociedad*, *14*(41), 263–285. Retrieved from http://www.revistacts.net/files/Volumen_14_Numero_41/14Tabares.pdf

Gutiérrez, R. T., & Ezponda, J. E. (2019). Technodata and the Need of a Responsible Industry 4.0. In J. P. Z. Bonilla & V. G.-P. Diaz (Eds.), *Handbook of Research on Industrial Advancement in Scientific Knowledge* (pp. 1–19). Hershey: IGI Global. https://doi.org/10.4018/978-1-5225-7152-0

Halbinger, M. A. (2018). The role of makerspaces in supporting consumer innovation and diffusion: An empirical analysis. *Research Policy*, *47*(10), 2028–2036. https://doi.org/10.1016/j.respol.2018.07.008

Jasanoff, S., & Kim, S.-H. (2013). Sociotechnical Imaginaries and National Energy Policies. *Science as Culture*, *22*(2), 189–196. https://doi.org/10.1080/09505431.2013.786990

Maxigas. (2012). Hacklabs and hackerspaces - Tracing two genealogies. *The Journal of Peer Production*, (2). https://doi.org/10.1017/CBO9781107415324.004

Niaros, V., Kostakis, V., & Drechsler, W. (2017). Making (in) the Smart City: The Emergence of Makerspaces. *Telematics and Informatics*. https://doi.org/10.1016/j.tele.2017.05.004

Pfotenhauer, S., & Jasanoff, S. (2017). Panacea or diagnosis? Imaginaries of innovation and the 'MIT model' in three political cultures. *Social Studies of Science*, *47*(6), 783–810. https://doi.org/10.1177/0306312717706110

Schot, J., & Steinmueller, W. E. (2018). Three frames for innovation policy : R & D , systems of innovation and transformative change. *Research Policy*, *47*(August), 1554–1567. https://doi.org/10.1016/j.respol.2018.08.011

Smit, J., Kreutzer, S., Moeller, C., & Carlberg, M. (2016). *Industry 4.0*. Brussels. Retrieved from http://www.europarl.europa.eu/RegData/etudes/STUD/2016/570007/IPOL_STU(2016)570007_EN.pdf

Smith, A., Fressoli, M., Abrol, D., Arond, E., & Ely, A. (2017). *Grassroots Innovation Movements*. London: Routledge.

Stilgoe, J., Owen, R., & Macnaghten, P. (2013). Developing a framework for responsible innovation. *Research Policy*, *42*(9), 1568–1580. https://doi.org/http://dx.doi.org/10.1016/j.respol.2013.05.008

Tabarés-Gutiérrez, R. (2016). Approaching maker´s phenomenon. *Interaction Design and Architecture(S)*, (30), 19–29.

von Hippel, E. (2017). *Free Innovation*. Cambridge, Mass: The MIT Press.

Wolf, P., & Troxler, P. (2016). Community-based business models Insights from an emerging maker economy. *Interaction Design and Architectures*, *30*, 75–94.