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A PLACE-BASED VIEW ON INDUSTRY 4.0 IN LOCAL PRODUCTIVE SYSTEMS

Marco Bellandi[1]

Lisa De Propris[2]

Erica Santini[3]

Abstract

Under the current wave of technological change, briefly referred here as Industry 4.0, windows of opportunity for a "manufacturing renaissance" might be opening in advanced countries. However, some concerns on both a further loss of old skilled jobs and a subservient role of many new jobs are widespread. This paper illustrates reflections and cases on the possible relations between technological change and a manufacturing renaissance in local productive systems (LPS), in particular those characterized by SMEs such as many Italian industrial districts. In particular, building on a recent approach labelled "Industry 4.0 Plus" (I4.0+), we argue that technologies should embed in organizational and developmental models, at local and trans-local levels, boasting renewed entrepreneurial and non-centralized models and an enhanced absorption of societal and environmental sustainability goals. That would help LPS to reroute towards new local product-service specialisations.

Keywords: industry 4.0; local productive systems; SMEs; alternative models of technological and organizational change; manufacturing renaissance

1. Introduction

In the last decades, the organization of globalisation and the delocalization of many labour-intensive activities to emerging countries has brought about in advanced countries a concentration of economic possibilities in core quarters of big cities, with a loss of skills, jobs and control over the value chain in many traditional industries, and finally a loss of identity for deindustrialising suburbs, smaller cities and industrial districts, whose manufacturing tradition was integral to shared senses of belonging. The Great Crisis blown up in 2007-2008 exacerbated indeed the difficulties of many weakened places and classes of workers (Dei Ottati, 2018). Not surprisingly, after the massive losses of job places, an increasing debate is about concerns on a further phase of hollowing out in manufacturing places of advanced economies, which a new advancing technological wave could take.

Indeed, this wave has emerged in the last two decades and has started to be felt more clearly in the last years. The pervasive penetration of digital technologies within production organisations, business models, and consumption models is shaping the way we produce, consume, communicate, move, generate energy, and interact with one another. The socio-economic landscape will be fundamentally altered (OEDC, 2016). In such a context, traditional productive organizations and territories are affected by both a broad range of opportunities and many risks associated with earnings inequality and a polarisation of jobs in manufacturing industries (Breemersch et al., 2019).

This wave has for sure redefined the forces shaping the industry competition (Porter and Hepperlmann, 2014). However, it is not yet clear what the new scenarios will involve. Some uncertain

[1] Department of Economics and Management, University of Florence - marco.bellandi@unifi.it

[2] Department of Business and Labour Economics. Birmingham Business School, University of Birmingham

[3] Department of Economics and Management, University of Trento

signals come from flows of reshoring and near-shoring (Bailey and De Propris, 2014). However, it seems clear that changes are not only at a technological level, but also in governance systems and institutionalized structures (Geels, 2002).

This paper proposes a few reflections and cases on the possible relations between technological changes and a possible manufacturing renaissance in local productive systems of economically advanced regions, under an approach referred as "Industry 4.0 Plus" (I4.0+) (De Propris et al., 2018). According to this approach, new technologies should embed in organizational and social innovations at local and trans-local levels, and could trigger solutions that renew the bases of local manufacturing specialisations, cross over sectoral boundaries, and address societal and environmental problems (OCSE, 2016). Such models are potentially alternative to top-down technocratic models of Industry 4.0.

Specifically, we consider models of industrial organization, labour relations, and knowledge management according to I4.0+ within paths of manufacturing renaissance for local productive systems characterized by populations of specialized SMEs, such as industrial districts. Decentralized bases of competences and tacit knowledge can combine with more codified knowledge as a non-casual source of exploration and exploitation of opportunities opened by digitalization of productive systems (Chaminade et al., 2019).

In what follows, section 2 introduces to I4.0+, section 3 discusses how alternative models can embed in local productive systems and allow rerouting to "manufacturing renaissance", section 4 proposes some implications on related place-base policies, section 5 concludes referring the discussion of the previous sections to a couple of more general reflections.

2. Industry 4.0+ for firms and territories

The contemporary wave of technologies is associated with enabling distributed and cross-media digital technologies, cyber-physical systems, internet of things and services, additive manufacturing (Hermann et al., 2016). It also includes the introduction of various types of digital infrastructures. The wave opens windows of opportunity for the emergence and stabilisation of new techno-economic paradigms of production and consumption (Bianchi and Labory, 2018). Indeed, its impacts extend to both the economic structure and the social configuration, modifying needs and routines of citizens, users, workers. Such transformation is sometimes referred as 'the Fourth Industrial Revolution' (Schwab, 2016). On the production side, in particular, new models inside the factory and between firms develop and are referred to so-called Industry 4.0, or Smart Manufacturing, or similar terms.

Potentially, digital technologies modify in depth the relations between producers and customers. Inside factories intelligent machines enhance both the productivity and the flexibility of productions for delivering 'mass customised' products. Between firms, digital networks enable the integration and orchestration of distant machines along the value chain. Products embody an increasing pool of new intensive knowledge services pointing out possible specializations in product-service systems (Kuijken et al., 2017). Customers can enjoy intrinsic functions of manufacturing goods and give away the ownership of the product itself. This is not *per se* a new proposition, but it is extending to a wide set of cases thanks to the opportunities given by digital technologies and adapted business models. Moreover, some of the new technologies allow an efficiently scaling-down of productions, and open up new opportunities for small producers that can tap into market niches for personalised, customised and innovative products. The cheaper activation of closer interaction between innovators-manufacturers-customers might be translated into more distributed patterns of manufacturing sites, whereby customers source or commission the-making-of-products locally. Finally, almost all new technologies can be deployed to enhance the environmental sustainability of production processes

and consumption via energy saving, bio-based products and fuel, remanufacturing and reusing of components.

These transformations are deeply re-shaping the industrial landscape and it becomes fundamentally important to explore the windows of opportunities and possible threats for local productive systems characterized by SMEs (OECDE, 2016).

2. 1 Opportunities and risks of Industry 4.0 in local productive systems of SMEs

Industry 4.0 solutions (I4.0) are opening opportunities of a new centrality for local productive systems (LPS) in old or post-industrialized regions and countries. However, how this opportunity is grasped depends on how public, collective, private strategies at different levels coordinate and manage related sets of risks.

In the debate over the interplay between I4.0 and local development, there is a palpable concern about the combined effect of digitalisation and robotisation on the balance between labour and capital inputs in production processes. Breemersch et al. (2019) find that the adoption of digital related process innovation is associated with job and income polarisation between operative functions and knowledge intensive directive functions (see Rifkin 2013; OECD, 2015). For sure, "digital technologies are upending the workforce" (Anthes, 2017, 315), though modalities are still unclear. Workers may move beyond their local labour markets and this can reduce the bargaining power of employers, but at the same time many employers can easily practise 'labour arbitrage'. For sure, these changes in the labour market are calling for new educational models that go beyond youth education but also include job retraining and long life learning, to ensure constant upskilling (Harari, 2017).

It is important here to consider firstly the issue of knowledge embeddedness in LPS. Knowledge generation and accumulation is the strongest lever of modern economic growth. Knowledge and competences continuously grow, hybridize, disseminate variously, and sometimes disappear. Each wave of technological change is the outcome of scientific exploration inside and across disciplines leading to breakthroughs in the 'useful knowledge'; new techniques are then selected by the market and exploited by the socio-economic structures (Mokyr, 2002). In LPS, the ability to capture, decode, translate, integrate and leverage the new 'useful knowledge' lies in the population of specialised firms and their local and extra local networks (Bellandi et al., 2018). This ability includes the availability of sources of knowledge generation and the effectiveness of sharing knowledge processes (Malerba, 1992). In such contests, the awareness, access to and adoption of a new technique depend indeed on the internal capabilities of firms, and collective readiness of communities and territories.

In LPS, many of the local agents work for the exploitation of a new technique, and some act as 'gatekeepers' in processing selected knowledge for reproducing and developing specific practices that could be incorporated in some ways within the production processes and the manufacturing tradition. Specifically, SMEs featuring some local productive systems, such as in many industrial districts across Europe, have been shocked by the radical changes in the industry competition and value creation processes. Manufacturing SMEs thrive within local productive systems where they are the vehicle of processes of increasing specialization and differentiation. The exploitation of new technique was historically driven by the balance between cooperation and competition playing a fundamental role in adjusting local business networks (vertical and horizontal), upgrading the pools of human capital based in specialized workers and entrepreneurs, and promoting incremental innovation processes and sustainable paths of development, economically and socially (Becattini, 2004). When this process works properly, the reroute of the socio-economic systems through new paths of development is a feasible solution (Bellandi et al., 2018).

2.2 Industry 4.0+

The exploitation and exploration of 'useful knowledge' at the core of a technological wave in LPS is mainly driven as a bottom-up process. When new techniques lead to radical changes the balance between cooperation and competition might be compromised (Dei Ottati, 2009). Moreover, increasing returns related to the mass and quality of resources organized at the local level and sunk in a high degree of interdependence between the main localised industry and the social territorial fabric increase uncertainty on un-coordinated investments within radical changes (Camagni, 1991).

In context of systemic rerouting, local institutions of a LPS play a critical role. They can support the up-grading of local skills, strengthen the authenticity of local products with cultural-based activities (e.g. the boot Museum in Montebelluna or the museums in the Jura Watch Valley), allow the coordination of different knowledge flows, and foster the building and working of multilevel platforms for networks of innovators (Crevoisier and Jeannerat, 2009; Asheim et al., 2011).

Studies on the processes of learning in various types of socio-economic eco-systems have investigated the relation between the exploration of new knowledge bases and the exploitation of a set of acquired knowledge (March, 1991; Gilsing & Nooteboom, 2006). For example, the early development phase of an LPS as well as its de-maturing phase, may be characterised by a high degree of exploration, which includes search, experimentation, and discovery. Whereas maturity would be characterised by more extensive exploitation, with phenomena such as refinement, efficiency, implementation. Systems that focus on exploration suffer high costs of experimentation; while those focussed on exploitation may be trapped in suboptimal stable equilibria. Therefore, an LPS, in order to enjoy longevity, should be able to balance exploration and exploitation, flexibility and variety in a reproductive way. This would need constant retraining, but also an alternative to dominant models of organization of labour envisaged in Industry 4.0, where decisive source of progress is knowledge developed and/or controlled by restricted élites. Concepts and experiences of "New makers" represent a possible alternative (Bianchi and Labory, 2018). Operative well-trained skills and competences are indeed still crucial in manufacturing phases and processes, such as matching of materials of variable quality and multi-purpose tools, quality control etc. Moreover, I4.0 technologies may be complementary to professional/creative processes that meet customer-specific demand in more complex ways and expand smart micro-manufacturing. All this suggests an enhanced concept of I4.0, i.e. the so-called I4.0+ (De Propris et al., 2018).

On the other side, new monopolies are emerging, in particular in ICTs, thanks to global-scale exploitation of private information gathered through the free release of Apps servicing the digital social networks (Kurz, 2017).

Such changes invest LPS from two sides. One concerns problems of fiscal sustainability, social welfare and inclusivity, participation and governance in the local society, to which we will refer briefly. The other concerns problems of market power in the vertical relations between local SMEs and large oligopolistic national and international platforms of digital based services of trade, finance, advertising, labour selection and training, enterprise resource planning and relationship management, collaborative knowledge and innovation networks, etc. (De Maggio et al. 2009). When LPS are not able to balance exploration and exploitation in a reproductive way, and their reaction to technological challenges is not strong enough, the risks of oligopolistic exploitation increase.

Note that the returns of local SMEs may be squeezed further by the standardised quality of digital services provided by large platforms not able nor willing to customize with respect to the very specific and differentiated needs of LPS. An even more important and real source of squeeze emerges when digital platforms are internalized by large manufacturing or trading companies that are big players in the SMEs' product or raw material markets. Consider a big player demanding small manufacturing suppliers/ customers, as a compulsory requisite for trading, to insert in a proprietary digital platform

that manages, for example, resource planning, quality and ethical standards, cost controls and budgeting. This is perhaps an opportunity for the small suppliers/customers to upgrade and learn about digital solutions. The dark side is that crucial business information is acquired by the big player, via the platform, and is used easily for reducing partners' margins of profits and independent decision-making.

Such risks expand when large digital platforms run by MNEs for managing their international value chains give them a crucial market power with respect to local SMEs trying to insert proactively within the same value-chains (OECDE, 2016). Digitalization may indeed push them under the control of centralized technocratic system driven by large companies.

3. Socio-technical relations fostering manufacturing renaissance

We consider now four sides of socio-technical relations of I4.0+ models (De Propris et al., 2018) in paths of manufacturing renaissance for LPS characterized by populations of specialized SMEs, such as in industrial districts.

A) Digitalization may empower micro-manufacturing models, where the efficient size of production is scaling-down and specialised small firms can access international networks of designers, customers and suppliers, with new solutions boasting flexibility and variety together with industrial efficiency. Here, producers co-develop personalized and innovative products with customers, meeting in original ways clusters of social, economic and environmental needs (Bianchi and Labory, 2018). Specifically, the greater adoption of digital technologies throughout the production process is shaping new interdependencies between the different stages, inside and between factories and firms. Moreover, the use of sensors, actuators, and data communication technology built into physical objects enable the tracking, coordination, or controlling of machines within networks, and favour short-term and long-distance exchange of information and goods (Manyika 2016). From this core, new interdependencies expand inside and between territories. This would support a renewed enlargement of market niches for personalised, customised and innovative products. Decentralized bases of operative (also manual and artisanal) skills can combine with synthetic and analytical knowledge (Asheim et al., 2011) as a non-casual source of exploration and exploitation of opportunities opened by digitalization. Lack of trained and motivated "new makers" and poor communication infrastructures weaken such opportunities and increase the risks of dependence within technocratic hierarchized models. Possible deficiencies on the side of business and customer services are dangerous as well. An important role is played here by the local institutions. Institutions, as a set of rules and conventions acting upon or within an LPS, and the related political and collective bodies, give differential incentives and coordination support to exploration and exploitation processes, but may also imply barriers related to rents-seeking and inertia (Bailey et al., 2010). The institutional context has to adjust consistently to the changing availability of 'useful knowledge' at a local and global level, in order to avoid technological barriers and societal conflicts that generate lock-ins (Bellandi et al., 2018).

B) Territorial servitization starts to be a real option for manufacturing SMEs in LPS that reroute to product-service specializations. Digital services enter manufacturing processes as an integral part of I4.0 solutions (Porter and Heppelman 2014, 2015), and service functionalities expand smart connected products where personalization is driven by direct relations with customers (Cusmano et al. 2010; Lafuente et al. 2017). The increasing amount of sharable information leads to different ways of approaching the customer. For example, design or product related data may be digitally delivered from a product designer/producer in an exporting country for printing in a target market. The symbiosis between traditional manufacturing sectors and service activities is enriched also by the

possibility of associating the value for the customer not to the ownership of the product itself but to the access to its intrinsic functions. As pointed out by Lafuente et al. (2017, 25): "Territorial Servitization can contribute to local competitiveness and employment creation through the virtuous cycle generated when a resilient local manufacturing base attracts or stimulates the creation of complementary knowledge intensive business services businesses, which in turn facilitates the creation of new manufacturers." This implies the spawning of new nuclei of know-how within the local system and an appropriate governance of new classes of local transaction costs related to the increasing density of sharable, ambiguous and immaterial characteristics in product-service exchanges. However, without a revamped support in terms of institutional solutions and entrepreneurial culture, territorial servitization may be weak (Bellandi and Santini, 2019).

C) Collaborative and reflective schemes of governance are needed for the adaptation of institutional frames and public goods specific to I4.0+ in LPS, which cannot be based just on records of past success. LPS and the related local societies risk to be locked-in regressive status quo of local oligarchies, or else to be dominated by the marketing and cultural strategies of external agents who not always give an undemanding support to participatory actions at local level. In any case, difficulties of alignment of incentives between the different local actors cannot be underestimated. Experimental projects of economic, social and cultural development of territories should be practiced deliberately within hybrid domains of collaboration (Aoyama and Parthasarathy, 2016), such as appropriate constellations of quadruple helix actors (Carayannis and Campbell, 2009). Quadruple helix initiatives more easily and explicitly connect to the purpose, or just the effect, of contributing to inclusive, smart, and sustainable paths of local/regional growth (McCann and Ortega-Argilés, 2015), open to global networks of production and knowledge (Barnard and Chaminade, 2017). They include, for example, engaged developmental universities, embedded policy-makers not captured by oligarchies, entrepreneurial SMEs and innovative start-ups together with anchored multinational enterprises under non-predatory incentives, actors of the civil society able to give new interpretations of local heritage and life experience, as well as non-local social networks within local initiatives on new common goods. Indeed, quadruple helix collaborations may help the I4.0+ approach, not only promoting an extended participation of the local community to the digital transition, but also integrating new interpretations of local traditions and heritage into business projects and social relations. The latter outcomes need social innovations impinging on experiences of life contexts (Moulaert and Sekia, 2003), and possibly support the development of smart productive solutions that, starting from local needs, are able to address successful solutions also for adaptation to broader applications (Crevoisier and Jeannerat, 2009). Similar potentialities appear, even if with different contents and requisites, in places and production/ innovation systems of either advanced or emerging economies (OECD, 2012; Arocena and Sutz, 2017).

D) Multi-scale and multi-actor place-based policies are part of the governance schemes referred in the previous point, but may be seen also as an autonomous side of the socio-technical relations supporting I4.0+solutions in LPS rerouting to product-service solutions. This side will be discussed in next section.

Summing-up, original ways to meet clusters of social, economic and environmental needs are surfacing and the social embeddedness of manufacturing SMEs in LPS might be a competitive advantage for SMEs (Bianchi and Labory, 2018). However, if the LPS lacks entrepreneurial dynamism and social cohesion, a regressive status-quo might be a probable result with local oligarchies preferring lock-in to change. Or else, a transition featured by technocratic models of I4.0 could emerge, dominated by the marketing and cultural strategies of external agents who not always give an undemanding support to participatory actions at local level. Neither technological innovation nor economic growth has *per se*, necessarily, in our world, long run positive effects on human, social

and environmental capital (Lundvall, 2017). Furthermore, technocratic approaches tend to leave unexplored and under-exploited the increasing needs and opportunities related to smart city and smart land solutions (Bonomi and Masiero, 2014).

4. A place-based view of policies supporting the digital transformation

New place-based integrated industrial policies under a I4.0+ perspective should have a clear systemic focus, represented by the provision of public goods specific to the development of LPS characterized by an extended division of labour among different manufacturing and service firms as well as institutional stakeholders. The aims at smart manufacturing and new knowledge intensive services to support rerouting to product-service specializations. In terms of methods, we maintain that the elaboration, implementation and control of the new policies should be understood as step-wise processes, developing around place-based projects characterized by value creation processes and driven by consensual models of value distribution potentially alternative to top-down technocratic models of I4.0 (Bailey et al., 2018). We articulate in what follows on two sides.

4.1 New specific public goods

New forms of asymmetries of information and competence divides might emerge with the absorption of radically new technologies leading to transaction costs and possible market barriers to knowledge sharing. The interrelations connecting supportive solutions to models of local non-centralized productive development suggest coordination problems that expand the need of appropriate policies.

In terms of policy contents, we argue that the presence of strong professional and entrepreneurial drivers and the creation of platforms and infrastructures to promote investment and awareness about the new available techniques can reduce barriers to the adoption of new value creation models, fostering a critical mass of experimental solutions (Bianchi and Labory, 2018). Public goods should address specifically the support to crucial factors of development, such as:

- Networking business culture among SMEs, together with good practices in innovative public funds, that targets and supports both product-service network projects and innovative start-ups/academic spin-offs in new specializations as a basis for developing a larger variety of related sectors;
- Openness of technological platforms that helps reducing local rents built on obsolete techno-organizational equilibria (where manufacturing and trade are separate business functions), as well as sheltering the local system from new large-scale oligopolistic power;
- Multi-disciplinarity that helps when technological shifts and organizational changes erupt; indeed, multi-disciplinarity is needed because of the transverse nature of new technologies and their intersection with the current societal and environmental challenges.

4.2 Multi-territorial scales

The local level of both industrial economies and related policies is fundamental but also dependent on dynamics that take place on larger territorial scales of interaction, across different places (large cities, industrial districts and smaller cities, rural systems, etc.), favoured by a sub-network of bridging actors, and multi-scalar institutional actors. Localism and "place-blind" interpretations as well should be avoided (Barca et al., 2012). This multi-territoriality and multi-scalarity is not a novelty when considering policies of local industrial development. However, some specific qualifications apply in face of current transitions:

- The higher urban nodes play specific roles within multi-disciplinary, cross-sectoral, and fluid spaces of innovation. "Place-sensitive distributed development policies" should both acknowledge such specificity and use it as a lever of the development of wider and plural

territories, without waiting for the effects of implausible trickling down mechanisms (Trullèn and Boix, 2017; Iammarino et al., 2019);

- A variation on this theme concerns relations between regional and national innovation systems, which are crucial for giving robustness to smart specialization strategies, coordinating regulations of international trade and investments, and helping contrast new digital-based oligopolies (McCann and Ortega-Argilés, 2015; Bailey et al., 2018; Bianchi and Labory, 2018).
- Platforms for mobility of high-skilled people and digital communication should help bridging across LPS and promote international collaborations through which wide *heterarchical* networks experiment novelties in product and services as a premise to mass customization in private goods and commons (Saxenian and Sabel, 2009; Sotarauta et al., 2011).

5. Conclusions

The perspective of I4.0+ solutions may trigger tendencies that renew the bases of local manufacturing specializations, cross over sectoral boundaries, and address societal and environmental problems (OCSE, 2016). Specifically, for SMEs local productive systems, digitalization empowers "micro-manufacturing" models, where variety and flexibility couples with industrial efficiency, while producers co-develop personalised and innovative products with customers, according to various social, economic and environmental sustainability needs. A source of effectiveness of this model is that it is potentially the basic unit of an organization of labour and knowledge between firms, inside territories and between territories, alternative to top-down technocratic models. Decentralized bases of operative (also manual and artisanal) skills can combine with synthetic and analytical knowledge as a non-casual source of exploration and exploitation of opportunities opened by digitalization and industry 4.0 (Chaminade et al., 2019).

The socio-institutional solutions and the policies of manufacturing renaissance needed to support such transitions are resentful of the core of Giacomo Becattini's vision of local development. Such policies should be both light and complex, reflecting a system-based view of trans-local and upper level relations, though not pretending to shape deterministically the profound factors of local socio-economic dynamics (Caloffi, 2017). According to Becattini (2015), the decisive factor of resilience of LPS is the confidence of their people, enterprises and institutions. They can constantly innovate if able to preserve individually and collectively such self-confidence, and create faithfully to local evolving but authentic productive cores, cultural heritages, and social identities.

In the transition discussed above, where traditional local manufacturing systems of SMEs are becoming something else, it is not sure that synergies dominate the tensions looming at the local level. One main issue is how and if adjustments of the organization of production can support the combination of new local and non-local knowledge with part of the traditional local productive knowledge. New classes of asymmetries in information and competences emerge with the absorption of radical technological changes and raise transaction costs and market barriers against positive local dynamics. The presence of strong professional and entrepreneurial drivers and the constitution of platforms of innovation and training reduce possibly the barriers and foster a critical mass of experimental solutions.

The population of business, social, education & research, institutional actors is in a state of constant flux. It oscillates between technocratic élites and the many who resist change, try to conquer rent positions, or just wait and see. Political and business leaderships aiming at progressive dynamics negotiate stepwise. It is a problem of openness of platforms to innovative actors, as referred before, but also of models of society, innovation, and labour for human and sustainable development. New

technologies feature evolving balances of public and private agency, leadership and participation, social and business targets. Evidence-based tools exploiting various types of digital technologies could help projects and implementation.

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