Industry 4.0 in industrial districts: innovation policy at Toy Valley district in Spain

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Abstract: This study is focused on how Industry 4.0 is diffused within Marshallian Industrial Districts (MIDS). It explains how MIDs initiate the adoption of Industry 4.0 through collective initiatives for digitization, bypassing many barriers to change through the utilization of a collective project built upon cooperation and competition, a key feature at MIDs. Results from interviews show a real living-lab built upon a place-based bottom-up oriented policy initiative co-designed by policymakers, collective actors and local firms, aimed to facilitate transition into Industry 4.0 in the Toy Valley district in Spain. The results contribute to the emergent literature on district digitization.

Key words: industrial district, Industry 4.0

JEL: O3, R1

1-Introduction

Digitization, and Industry 4.0 specifically, is transforming entire businesses, companies, industries and platforms through the introduction of digital technologies and paradigms (e.g., key enabling technologies, such as *Artificial Intelligence, Cloud, Augmented Reality, IoT, Social Media, Online Stores, Cybersecurity*, etc.) enticing a transformative digital disruption (e.g. Autio et al., 2018). Industry 4.0 constitutes the digitization of manufacturing and is starting to be considered within the SMEs literature (Müller et al., 2018), regional innovation systems literature (e.g. Bellandi et al., 2019; de Propris & Bailey, 2020), global value chains (Kano et al., 2020; Sturgeon, 2019) and cluster literature (e.g. Götz & Jankowska, 2017; Hervas-Oliver et al., 2019). These related strands are also being developed jointly to a paradigm shift in the new industrial policies, which represent the implementation of the *Digital Single Market* initiative by the European Commission[1] on many fronts, such as the creation of *Digital Innovation Hubs* across European Regions. The study of Industry 4.0 is timely and requires research at the

[1] https://ec.europa.eu/info/strategy/priorities-2019-2024

regional level and the cluster level, analyzing also new possibilities of regional industrial policy (de Propris & Bailey, 2020).

In this study, we focused on the role of Industry 4.0 in Marshallian Industrial Districts (MIDS), where evidence is scant (Bellandi et al., 2020; Hervas-Oliver et al., 2019) and this study's goal consists of showing and building theory from the understanding on how MIDs initiate the adoption of Industry 4.0 through collective initiatives for digitization. MIDs constitute a special social-based context where changes are complex due to cognitive assumptions (e.g. Glasmeier, 1991) and SMEs face many barriers related to their own limitations (Müller et al., 2018). Thus, we attempt to show the development of a real living-lab built upon a place-based bottom-up oriented policy initiative co-designed by policymakers, collective actors and local firms, aimed to facilitate transition into Industry 4.0 in an MID. Thus, this study presents and analyzes the early stages of an ongoing place-based innovation policy, supported in a living-lab, aimed at facilitating a collectively-based transition towards Industry 4.0 in a traditional Marshallian Industrial District (MID) where SMEs predominate: the *Toy Valley* in Spain. As Leminen et al. (2012) point out, living labs offer an R&D methodology through which innovations are created and validated in collaborative real-world environments, where user experiences reveal future directions of product and technology development. Living labs build on an intense co-development with users (innovators, co-designers, co-producers, and entrepreneurs in regard to new products) and the end result is expected to better solve customers' needs and wants.

The Toy Valley is labelled as a typical MID (Balland et al., 2016; de Marchi et al., 2017) and, as explained below, it has undergone a very intense process of diversification from the early 1990s on. At the present time, the *Toy Valley* is a totally diversified manufacturing hub that, starting from toy manufacturing at the turn of the XX Century, gradually evolved to be transformed as a manufacturing hub focused on plastic-related products and technologies. These are applied to different markets such as household (kitchen tools and products such as lunch-boxes, buckets, etc.,), food industry (food containers, plastic-bottle solutions, packaging), automotive industry (metallic components such as molds, rotation motors, etc.), health (health care containers, baby products such as baby bottles, baby care kits, thermoses, etc.), toys or furniture, among many others including machinery and logistic for these products. Through qualitative analysis based on 54 face-to-face interviews in the 2017-2020 time period, this study contributes to enriching the still emerging strand of Industry 4.0 in Marshallian Industrial

Districts, complementing extant works (e.g. Bellandi et al., 2020; Hervas-Oliver et al., 2019). This study's approach also contributes to place-based policy literature (e.g. Bailey et al., 2018; Magro & Wilson, 2019) and specifically to innovation policy focused on Industry 4.0 (e.g. de Propris & Bailey, 2020). Overall, this article contributes to MIDs (e.g. Bellandi et al., 2019; Belussi & Hervás-Oliver, 2016) by presenting evidence of new policies and mechanisms that reinforce the socio-economic logic that drives innovation in those socio-economic concentrations.

The remainder of this study is as follows. After this introduction, Section Two present the literature review. Then, Section Three presents the setting, the Toy Valley MID. Section Four shows qualitative results and the last Section, Five concludes.

2-Industry 4.0 and SMEs in MIDs

2.1-Conceptualization of Industry 4.0

As Figure 1 shows, the evolution of the search of the "Industry 4.0" topic reveals the strength of interest over time for the related concept, taking off in 2014 (Industry 4.0). See figure 1.

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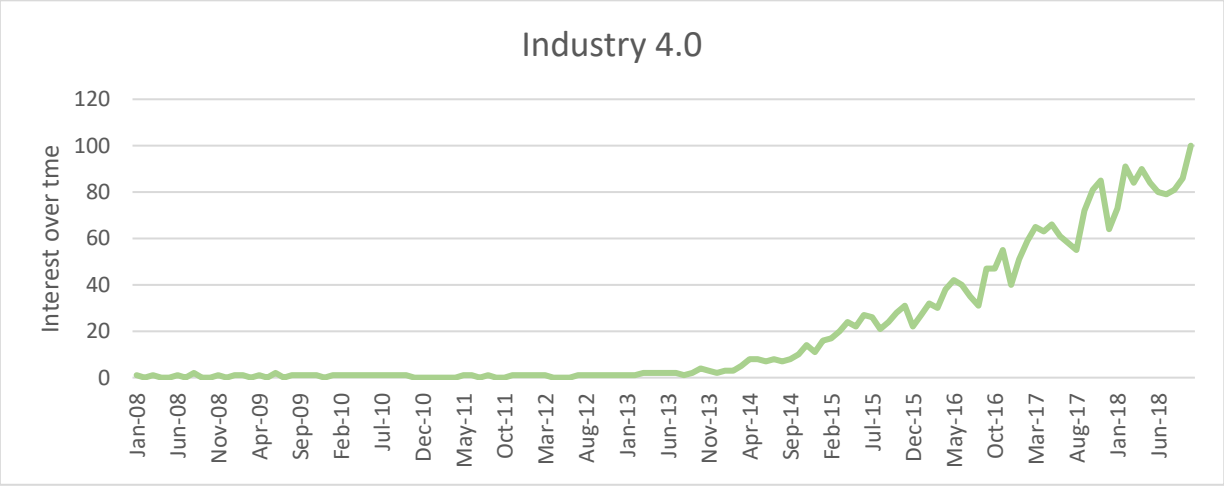

Figure 1. Evolution of the term Industry 4.0 and its interest over time. Data source: Own Compilation with *Google Trends* data[2]; data reflects research interest: 100=maximum popularity; 50= medium popularity and 0= lack of popularity.

[2] https://trends.google.es/trends/explore?date=all&q=Industry%204.0

Digital manufacturing is related to Industry 4.0, smart manufacturing or even industrial internet of things, referring to changes, activities and capabilities to obtain opportunities from the new digital paradigm (see Kagermann et al., 2013 or Rindfleisch et al., 2017). The concept includes different digital enabling technologies, such as *the Internet of Things, Cyber-Physical Systems, Additive Manufacturing, Big Data, Artificial Intelligence, Cloud Computing, Augmented and Virtual Reality, Cybersecurity, and Blockchain,* among others, all of them defined in Appendix I. See Appendix I.

All in all, European countries have implemented different yet related programs aimed at digitizing their economies and advancing knowledge on advanced manufacturing. European countries are promoting the advanced manufacturing and digitization tandem, but are also promoting advanced knowledge in a broad range of service industries such as finance, transportation or cell and gene therapy. National programs across the EU are those such as *Industrie 4.0 Austria* (in Austria); *Smart Industry* (The Netherlands); *Made Different* (Belgium); MADE (Denmark); *Smart Industry* (Sweden); *Industria 4.0* (Portugal), Spain (Industria Conectada 4.0 program), the Prümysl 4.0 initiative of Czech Republic or *Piano Industria 4.0* (Italy), with different programs. These national programs are embedded within the EU *Digital Single Market* strategy to digitize Europe. China does the same with its "Made in China 2025" program and the "Super Smart Society" plan of Japan in 2015 (see more at Liao et al., 2018).

2.2-SMEs in MIDs: barriers and solutions to digitize

Despite the high intensity of inter-firm cooperation in MIDs being recognized, literature on SMEs points out their difficulties to co-operate with external partners to access to specific knowledge or public funding for Industry 4.0 (Issa et al., 2017), a fact that can also be found in districts for digitization (Hervas-Oliver et al., 2019). Basically, we refer to the fact that SMEs face constraints in everything that is beyond their focal technical expertise, such as financial limitations, lack of strong technological capacity to accommodate technological shifts beyond existing lock-in technological paradigms, weak IT infrastructure or the absence of well-clarified strategy plans and technology road-maps. In addition, SMEs in districts are also dependent of those technology gatekeepers or leading incumbents that orchestrate local networks and control technology shifts (e.g. Hervas-Oliver & Albors-Garrigos, 2014; Lorenzoni & Lipparini, 1999). To some extent,

local networks of SMEs are to certain extent dependent, at least for technology purposes and innovation, on the leading incumbents that organize those networks and orchestrate the knowledge that circulates within.

SMEs in districts, like other types of SMEs, do not know what to do about digitizing, due to their low level of capabilities to digitize and insufficient resources (Sommer, 2015), 2015). As Matt et al., (2020) and Yüksel, (2020) show, smaller companies present poorer integration of digital enablers and knowledge management in manufacturing facilities. As digitization is a capability in itself, related to IT and information systems, digitizing requires organization capabilities and knowledge management that enable learning and capabilities reconfiguration for introducing digital enablers in SME resources and capabilities. Such knowledge and assets pre-condition, especially those related to IT and software know-how that underpin digitization, however, is not particularly well developed at SMEs. Similarly, digitization also needs investments in machinery and facilities, supply chain re-organization, which are also more complicated in SMEs (Müller et al., 2018). Transformation of capabilities for digitization, starting with IT itself, in the sense of Teece et al. (1997), requires explicit plans, objectives, investments and resources, that is, sound strategies committed to change, among others (Fitzgerald et al., 2014; Porter & Heppelmann, 2014, 2015). Lastly, as Moeuf et al. (2020) indicates, poor strategies by SMEs constitute also a potential risk in achieving digitization.

When zooming to districts, as Hervas-Oliver et al. (2019) evidence, there are many barriers to SME digitization but in MIDs there also exists the possibility of the *collective action* for Industry 4.0 transition, a special feature of district SMEs that is not found outside districts or agglomerations. These collective initiatives, supported by an atmosphere of co-operation/competition and social ties, produce knowledge accumulation and learning with less risk and cost for SMEs. In a similar way, Bellandi et al. (2020:84) refer to the same idea with *collective rerouting* that occurs at the system level and permits the incoming knowledge and its associated technological change and transformation of networks to occur, supported by the existing social relations and institutional local system. Therefore, despite being constrained by definition, SMEs in districts can effectively develop collective actions based on networking and social ties that might facilitate digital change, vis-à-vis non-district firms.

Thus, facilitating change in industrial districts and their SMEs through collective action, following Hervas-Oliver et al. (2019) requires three basic pillars for doing so. First, leveraging *collective actors* and their support for legitimizing technological transitions and new technologies. Second, developing *place-based innovation policies* that account for local/regional context and specificities. And third, organizing bottom-up and SME-oriented collective actions and initiatives for promoting inter-firm learning, interaction and networking (i.e., open innovation) for value co-creation in a focal theme, in this case in digital technologies.

Collective actors are those entities such as trade or professional associations, public technology transfer offices (TTOs), or even universities, among other support stakeholders, that combine the complex layers of technology, institutions and social aspects, support technology transitions and even legitimize new industries (e.g. York et al., 2016). Collective actors may act as supporting institutions, developing a function of brokerage on regions and clusters, fostering innovation by acting as mediators and facilitators of inter-firm interactions to spatially diffuse knowledge.

As regards regionally-based or territory-focused initiatives, collective actors, either public or private agents, establish some governance structure, formal or informal, on the local networks and are also capable of initiating or supporting collective initiatives. For this reason, collective actors need to cooperate with policymakers in order to co-create regional advantage, building upon regions' existing advantages. This co-operation for co-design of policies, constitutes place-based policies built upon endogenous initiatives that are embedded on the institutional local context and existing social relationships and avoids spatially blind approaches (Bailey et al., 2018). Hence, these types of place-based policies are initiatives developed and built upon associative structures of governance that are bottom-up, decentralized, open, consultative and aimed at facilitating coupling and coordination of actors. Effective innovation policies are bottom-up, endogenous and the result of negotiations, adaptations and incremental changes in response to changing conditions, which are constructed upon creative actions and collective decisions that take into account local social conditions and the interactions of actors in relation to the policy, as stated by Magro and Wilson (2019).

Overall, these innovation policies, which are particularly aimed at leveraging Industry 4.0 transition can be supported and led by place-based policies that really consider spatial

specificities that leverage the necessary institutional change for promoting collective action for digitizing. Similarly, de Propris & Bailey (2020) state that regional industrial strategies for Industry 4.0 require tailor- made policy actions embedded in and linked to the specific needs and available resources of regions, starting with the existing knowledge and institutional base in that region. These policies can be very effective removing specific local barriers associated to SMEs, as well as coordinating collective efforts, aligning local stakeholders and developing a collective understanding of the new technology and facilitating the development of an institutional framework that stimulates change (Bailey et al., 2018), even reshaping existing institutions to legitimize digital transformation (Hervas-Oliver et al., 2019).

Place-based innovation policies, fueled by collective actors in MIDs, need to activate networking or open innovation (Chesbrough, 2003) for SME interacting, exchanging and learning on Industry 4.0, bypassing thus existing barriers such as poor strategies, lack of internal resources and investments or low level of knowledge management capabilities. Therefore, open innovation or firms' boundary-spanning search strategies for accessing Industry 4.0 knowledge should be part of the place-based policy, emphasizing the core importance of external sources of knowledge to a firm's innovation and performance. This literature on regional innovation systems (Cooke, 2001; Isaksen & Trippl, 2016) is based on the idea of open innovation, therefore, open innovation and networking policies need to be considered in place-based innovation initiatives to develop Industry 4.0.

3- Setting: The *Toy Valley* district

The Toy Valley cluster is constituted by the municipalities of *Ibi, Tibi, Onil, Castalla* and *Biar* in the Valencia Region, Spain. At its inception, it was fully dedicated to toy manufacturing, using metals, wood and, later on, plastics and other electrical and mechanical mechanisms. At the present time, Toy-Valley is a multi-industry cluster with many competencies and technologies built up and developed from those origins, serving at the present time a huge and diverse range of industries with those technologies (metallic products, plastics, and other technologies) such as automobiles, machinery and equipment, electrical components, carbon fiber, advanced plastics, toys, plastic and

cardboard containers (general packaging for food and beverages, healthcare, baby care, pharmaceutics and other related industries).

The Toy Valley has been labelled as an *industrial district* (e.g. Balland et al., 2016) and it constitutes a key manufacturing hub that present 7,000 manufacturing jobs within a population of 40,000 inhabitants and with around 40% of the labor force dedicated to manufacturing, doubling the EU 20% target. At the present time Toy-Valley is a leading diversified industrial space for manufacturing processes, with world-class foreign global multinationals[3] attracted by local capabilities, where plastic-related technologies (packaging, molds, plastic components, etc.) predominate. These global firms acquired local firms to enter the valley. The Toy Valley has around 400 firms, 90% SMEs with 9-49 employee size on average. Its export ratio accounts for 60% of total production. The district has ample support institutions, including the public-private partnership technological institute (AIJU), centered around plastic, metallic and production manufacturing capabilities; the IBIAE private trade association, integrating the majority of local firms; the "Innovative Toy Valley Cluster", a local innovation club that gathers the most innovative firms to foster co-operation, knowledge transfer and lobbying; also, there are plastic- and metal-dedicated vocational training centers, specialized press and others.

As regards collective actors, AIJU[4] is a public-private technology transfer organization (TTO) that can be considered "vertical", as it is primarily focused on plastic-related technologies, focused on production- and plastic-related technologies that are the core technology in that territory, with facilities of over 6,000 m^2 with modern equipment and 80 highly-qualified staff. Personnel at AIJU possess PhDs (11%) or an advanced university qualification (around 50%), the rest being technical assistants or administrative support. It has training labs, technical labs, manufacturing labs, and even a toy lab to test toys on children, as toys are still a significant sector in the territory. Services provided include those such as manufacturing upgrade, user and trend market studies, development of industrial products, testing, product certification or consultancy for obtaining public

[3] (e.g. SMURFIT KAPPA, packaging- focused; JOHNSON CONTROL or SGR, both first-tier automotive-component firms)
[4] See more here: https://www.aiju.es/en/about-us/#about

financial support. One of the most interesting facts of the AIJU institute is that its Board of Directors' composition includes public policymakers (from IVACE, Innovation branch of the Regional Government), local business people (from the most active and innovative firms) and top executives of AIJU itself. This public-private partnership, where local firms participate in the decision-making process, makes the institute very embedded in local business affairs, legitimizing its leadership in proposing and executing place-based policies commissioned by the Regional Government. Around 40% of funding comes from the public budget (from IVACE) and the rest is obtained from services and technology transfer fees (including transfer, European Projects, consultancy or testing services, etc.).

Similarly, the "Innovative Toy Valley Cluster[5]" is a local innovation club to improve firms' competitiveness. It is an innovation-focused and socially-based association led by AIJU innovation leader (Mr. Joaquin Vilaplana), fostering collective strategic reflection, promoting debates on competitive intelligence, technology forecasts and also functioning as a *lobby* for local interests (relationships with local city councils to upgrade industrial sites and infrastructure or promoting joint purchasing, among other services). The innovation club also holds regularly key notes and seminars for training, new technology demonstrations, discussing joint international trade initiatives to bring global buyers, etc. It is run by a "cluster manager", uses the AIJU facilities to meet and it recently was awarded with the *Bronze* category of Cluster Management Excellence initiative.

These collective actors, along with the IBIAE local trade association (with legal, lobbying, information and knowledge support for local firms), constitute the basic pillars of the support infrastructure in the district, which is understood as a *meta-organization.*

4-Qualitative research: analyzing the Industry 4.0 living lab.

4.1-Field study

This study utilizes a qualitative approach, encompassing 54 direct face-to-face interviews with business representatives (20), policymakers (2), and support organization representatives (5) from AIJU and IBIAE. Field work started by 2017 and was ended by

[5] See more here: https://www.clustervalle.es/

2020. Some interviewees were interviewed at least twice at different times and for different purposes (27 informants with 2 interviews to each); some of them even more than 2 times in a more informal context (spontaneous talks from joint attendance to seminars, congresses, technology demonstration events, etc.). The latter were not computed.

In 2017 the first round of interviews was conducted to develop the main draft of the Regional Innovation Policy at the Valencian Region (Spain), commissioned to some of the authors of this study by the Regional Government to design an industrial plan for the next 6 years (2018-2023, named PEIV[6]). One key point from PEIV was its place-based orientation and bottom-up approach, using local clusters and/or industries as unit of analysis; PEIV considered first *place* and invited local stakeholders to be part of the design, discussing, interacting and finally co-designing the output through a joint decision-making process. From those interviews and meetings (some of them could be considered focus groups) the functioning of the district and its most important strategic requirements were learned and formulated, including the specialized highly-skilled workers shortage (primarily in molding and plastic-injection related technology) and the formation of a new training program at AIJU; providing more industrial plots to meet rising demand for the entrance of new business to the territory (more than 100 firms on a waiting-list) as well as the expansion of existing facilities and the capital inclusion of sustainability-oriented (circular economy programs, energy-saving grids, recycling plants and protocols, etc.) and Industry 4.0 actions (digital enablers testing, training programs, etc.) in the policymaking portfolio. During the second stage of interviews (2019-2020) we were entirely focused on the development of a "star" initiative for Industry 4.0: the "living-lab" Industry 4.0 platform demonstration project. The latter constituted a direct action from the PEIV implementation.

It is important to notice that we were surprised of the intense social capital existing in the district (Ibi, its principal town only has around 20,000 inhabitants, and everybody knows everyone). They manifested that companies fiercely compete and do not cooperate too much, but socially knowledge circulates at a very high speed. For instance, they pointed out that informal lunches and other social events among friends are fully devoted to

[6] Valencian Manufacturing Strategic Plan, see more here: http://www.indi.gva.es/es/web/industria-e-i-d-i/estrategia-politica-industrial

discussing new opportunities. As Smurfit Kappa CEO, formerly the owner of the local company acquired by the multinational, reported:

"During lunches with friends at weekends, we have small talk…..but we all end up searching for new local opportunities like new capabilities in local firms, new potential markets, new technical solutions from other industries or gossip about skilled workers that are considering mobility to another company; definitively we exchange knowledge…."

They also commented how easy it is to do business at the local level. As a former plant engineer of a leading local toy firms, stated[7]:

"The virtuous local assets not only present plastic or design capabilities, but also sound logistics, good public research infrastructure, extensive market channels and also recognition of the local district as a major industrial hub for business".

In 2020, the second round of interviews were fully dedicated to development of the Industry 4.0 initiative, which was prioritized above the rest. The most important question for the initiative was: how to implement Industry 4.0 in the district. As discussed with policymakers and stakeholders, there were different alternatives. The first alternative was based on traditional "innovation vouchers" for digitization, supported by some digital enabler demonstration events and seminars, started by 2018 and going on every year. The innovation vouchers, named *Digitaliza-CV* program, launched by IVACE (innovation office of the Regional Government) includes any initiative to digitize SMEs, like including sensors for IoT, cybersecurity, acquiring Big Data software, etc., funding around 25% with a cap of 200,000 in three fiscal years for each SME. This was immediately implemented, as innovation vouchers are a classic in the repertory of innovation offices at the Regional Government.

Another alternative, discussed latter, consisted of using the network of technology transfer offices, well located at manufacturing hubs around the region, for developing technical *simulators* to show local SMEs the potential of Industry 4.0 technologies; as it were, a permanent exhibition site for showing some digital enablers and their potential impacts on local SMEs. Lastly, the third alternative, consisted of developing a living-lab platform for an Industry 4.0 demonstration in a real company, developing *in-situ* digital technologies for plastic-related technologies and transferring that knowledge to the rest of the territory. Finally, as the first initiative was not really pushing SMEs, especially

[7] Marcelino Huerta, former Top executive at FAMOSA

small ones, to transit into Industry 4.0, the third alternative was chosen and implementation started at the end of 2019, just when our second field work started.

An interesting point is the fact that the specific policymaking for the Toy Valley plastic district was discussed by policymakers (IVACE) and AIJU representatives (including executives and local business) in a bottom-up approach to empower local business, through its local TTO as its representative, to co-design an initiative that can better respond to local needs both in design and implementation.

"This bottom-up approach recognizes that local firms are included in the negotiation and decision-making process not only to design through PEIV, but to implement, and give great importance to local actors such as technology transfer offices to propose what really works".

The company chosen for investing in digital technologies to implement Industry 4.0 was *"Vicedo Martí"*, an advanced SME with more than 30 years of experience. This SME manufactures plastic related products, such as household or health care products. With a range between 40-50 employees and 5 Million euros in revenues in 2019, it constitutes a perfect example of a local SME plastic-focused company. Its typology of local "average" SME, albeit with advanced technology capabilities for its category, represents a model that other similar SMEs can follow by imitation. The firm is innovative with a small R&D department, showing robust financial indicators (in 2019 a ROA=15% and a ROE=40%[8]).

As a top executive from AIJU commented about the implementation of the policy:

"Choosing the local company for establishing the demonstration was our responsibility. The idea was not to choose the best and most advanced local company but that with enough capabilities to host the project and also being able to represent a model for other SMEs to follow; other SMEs should think that they can also do it".

"There are larger local firms and more technology-advanced ones, especially those that are multinationals. These firms are not the focus of this policy, as they have their own large and well equipped R&D departments, along with tailored-made digitization programs form their corporate groups, as well as strong financial muscle".

"The goal of this "living-lab" is to show to the district that all SMEs, to a certain extent, and with different technologies, can be gradually digitized".

The agreement between IVACE and the local consortium led by AIJU to digitize, includes the focal company receiving the investment to implant all digital technologies, supported by a coalition of consultants (mostly from IT industry) and AIJU itself. The technology

[8] SABI Bureau van Dijk database, accessed in September 2020.

is developed to generate best practices that can be subsequently transferred to the district, complementing seminars, training and other types of actions to support the digitization of SMEs. The fact that the contract explicitly includes the catch that the factory has to be open for arranged visits from local SMEs, even competitors, is a demonstration that the collective project is built upon a cooperation and competition dimension existing in industrial districts. This type of demonstration platform is supported by a social capital intensive local trust-based context that facilitates cooperation and competition and builds on open innovation.

As members of AIJU explained:

"The idea is to test digital technologies in local industry in a real way and diffuse them to the entire territory, through training, seminars and also direct technology transfer projects"

"It is open doors because we want to signal that digitization is a must, showing a real and reliable road map to SMEs to digitize"

The IT consultants employed are also part of the project, as thus the IT industry can be adapted to local technology needs, favoring the "translation" of the digital technologies to lock-in technologies and paradigms. As members of AIJU explained:

"Not only developing digital tools, we are interested in showing local technology and its specificities to the army of IT consultants that sell one-sizes-fits-all digitizing projects to our SMEs. Thus, those IT firms will easily adapt standards to local requirements. Our goal is the digitization of the territory, enabling also the formation of a new sub-industry of IT supporting it"

Digital technologies integrated by AIJU and other networks of subcontractors from the IT industry (e.g. *Sothis*, a leading IT consultant) included sensors and IoT, 3D printing, augmented reality and manufacturing data analytics (like Big Data), logistics through data capture by drones in warehouses or artificial vision, among others. For instance, augmented reality works for inspection of molds (to find imperfections that are not easily visible) and also for training, giving to employees instructions and checklists embedded in an eye-ware. This way, before commencing, assembly workers at the production line can visualize, step by step, all the different processes and criteria, and also simultaneously the assembly process. This innovation not only improves product quality but permits non-skilled workers to be less costly and better trained.

When interviewing local firms, all of them (20 firms) recognized the value of the policy and its potentially positive effect on the territory. As one interviewee commented, referring to the bottom-up designed living-lab:

"I like this way, because the visualization of digital tools is real and occurs in this local industry".

Another local entrepreneur agreed, adding that:

"It is an effective way to show us the steps to digitize our organizations. Replicating is impossible, because each firm is different, but you can imagine how some of the technologies can improve certain areas at your own firm. The project adds value to the territory".

The collective project aims to diffuse knowledge to the territory and to diffuse best practices for those SMEs that might experience troubles associated with poor capabilities and weak IT systems to support digitization. One interviewee stated that:

"Most local SMEs, not the large ones, do not have proper IT systems and capabilities. Digital change, therefore, is difficult because of the latter and the lack of financial resources. The living-lab [at Vicedo Martí] shows us the roadmap to follow. Companies will pick up those technologies that can better fit their own systems and can even see in advance the potential effect on performance. Not all digital technologies are necessary, it will depend on the type of firm".

Lastly, one local businessman pointed out that:

"To me the most important message is that we need to change, this is a new must and having the pilot project helps us to start."

4.2-Discussion of results

As observed, SMEs in districts can effectively develop collective actions based on networking and social ties that might facilitate digital change, vis-à-vis non-district firms. The logic of co-operation and competition existent in MIDs renders rapid circulation of knowledge that permits the multiplicity of the local know-how through accumulation. The cooperation and the social dimensions thus permit a collective initiative that could be harder outside MIDs. The diffusion of the knowledge not only occurs through inter-firm interaction but from imitation. The technology from the living-lab could be imitated and spread within the MIDs because the new digital enablers are "translated" into the local language and lock-in technology and assumptions. As Staber (2009) points, in districts learning from others (imitation) can be as important as learning with others (interactions).

The living-lab accounted in the field study qualifies as a living-lab in both components and principles. According to Bergvall-Kåreborn et al. (2009), a living lab is a user-centric innovation milieu built on every-day practice and research, with an approach that facilitates user influence in open and distributed innovation processes engaging all relevant partners in real-life contexts, aiming to create sustainable values. This is what we evidenced in the Toy Valley living-lab through interviews. In the living lab at *Vicedo Marti* SME, where members from the collective actor AIJU interact, test and learn about how Industry 4.0 enablers work in a real production process, engaging also with external IT members that provide additional technical support.

Following Bergvall-Kåreborn et al. (2009), the *key components* of living Labs are encountered in the Industry 4.0 living lab at the Toy Valley. The *ICT & Infrastructure*, referring to the role that new and existing ICT technology can play to facilitate new ways of cooperating and co-creating new innovations among stakeholders, in our case around digital enablers (augmented reality, drones in warehouses, artificial vision, etc.), *Management*, accounting for ownership, organization, and managerial aspects of a Living Lab, in this case managed by the focal SMEs and the AIJU temporary coalition. The Living Lab *Partners & Users* arranged a team of experts that put together knowledge around plastics, IT and manufacturing (like the IT support partners). *Research*, which presents the collective learning that occurs in the lab, in this case about the digital technologies and their impact on plastic manufacturing processes and, finally, *Approach*, that stands for methods and techniques that emerge as best practice within the living-lab environment, in all different digital technologies (e.g. augmented reality for training or for mold inspection).

Similarly, the project meets the key *principles* of living-labs. *Openness*, to different partners, AIJU, IT firms and other equipment suppliers, as well as the open-door policy to show advances to the district; *influence*, the legitimacy of users (*Cabedo Vicens* and AIJU) as active and competent locally embedded partners and domain experts; *realism*, by which innovation activities are carried out in a realistic, natural, real life setting; *value*, the importance of its outcome in terms of economic/business value of digitization for the local industries and SMEs, especially for the territory as a whole; and, *sustainability* that

refers both to the viability of a Living Lab and to its responsibility to the wider community in which it operates, i.e. the district.

As regards the role played by collective actors, it is important to stress their additional features that account for those including topics and initiatives that are future oriented and are aimed at bringing together complementary capabilities from different actors and industries, enticing cross-fertilization of ideas and promoting joint or collective action (e.g. Uotila et al., 2012). *Collective actors* navigate between the interplay of technology and institutions, even legitimizing new industries and supporting the digitization transition (e.g. Aldrich & Fiol, 1994). Overall, this place-based policy, resulting from a bottom-up approach and facilitated by collective actors has achieved:

-Interacting with policy-makers to lead bottom-up and place-based digital initiatives.
-Removing potential institutional and SME barriers to digitize the territory.
-Aligning collective interests of the local district.
-Creating awareness on the necessity to change towards digitization.
-Offering a supportive institutional environment to promote action and change through a real digital platform for local firms.
-Presenting, developing and legitimizing new (digital) paradigms.
-Developing a collective understanding and a real implication of local stakeholders in order to implement the initiative.
-Supporting and facilitating digital change for the exploitation of the cooperation-competition logic of MIDs.
-Selecting leading local front-runner innovators to benchmark for other local SMEs.
-Supporting the adaptation of complementary industries (IT) to develop tailored to the territory solutions to facilitate change in the district.

5-Conclusions

This study's goal consists of understanding how to design effective innovation policies to support a collective action to digitize traditional MIDs. These policies utilize collective actors as enable mechanisms and thus remove potential barriers associated with SMEs in districts and grasping the opportunity that cooperation and competition logic offers in MIDs, vis-à-vis SMEs located outside districts. This advantage offers space for policy-

making capitalizing on a key distinct feature of SMEs located in districts: cooperation and social ties. Through a qualitative analysis based on 54 face-to-face interviews in the 2017-2020 time-span, this study contributes to enriching the yet emerging strand of Industry 4.0 in Marshallian Industrial Districts, complementing extant works (e.g. Bellandi et al., 2020; de Propris & Bailey, 2020; Hervas-Oliver et al., 2019; Pagano et al., 2020). For this purpose, this study presents and analyzes the early stages of an ongoing place-based policy aimed at facilitating a digital-focused living lab in a real SME in the *Toy Valley* in Spain. This study permits us to learn about how to design effective Industry 4.0 initiatives for MIDs.

Results from the Industry 4.0 living-lab initiative show that (i) local collective actors are key facilitators that can legitimize and orchestrate collective actions that leverage the cooperation-competition dimension of MIDs; this can be operationalized through, (ii) living-labs that favor networking from multiple actors to build digital capabilities in the territory; these living labs can be built upon (iii) bottom-up place-based innovation policies, co-designed and negotiated with policymakers and local actors (both firms and collective ones). Living labs are not necessarily the only means to facilitate Industry 4.0, as other types of programs might also work (other types of collective projects, workshops, courses, seminars and formal/informal business interactions, see Pagano et al. (2020), but in this particular case it proves to be effective, at least in its initial stages. Overall, this place-based policy to digitize allows us to overcome all the barriers to change associated with SME constraints (financial, strategic or IT capabilities, among others; e.g. Moeuf et al. (2020).

The manufacturing plan for the entire region enabled local industries and territories to enter into dialogue directly with the Regional Government and its innovation branch (IVACE), meaning that those territories and industries could influence, in no small part, how to spend innovation funds on interventions that they would co-design and implement within their local zones. In practice, this bottom-up approach recognized each cluster/industry as a unit of analysis with actors (collective actors primarily) to include in the policy-making design process. One tangible result of this new orientation in the region was the co-design of the Industry 4.0 for the “Toy Valley” district.

The co-design and subsequent implementation of the "living-lab" for Industry 4.0 was strongly rooted in the idea of embeddedness that is pervasive among industrial districts. This approach means that the point is not applying the best high-tech technology of Industry 4.0, such as best practices from the automotive industry, but rather to generate a gradual and tailored digital transition to generate upgrading of existing plants within a context of traditional manufacturing existing in each territory, adapting digitization to local technology and know-how nuclei (*à la Bellandi*). This means not only avoiding one-size-fits-all but including local contextual specificities. Therefore, in terms of innovation policy, the living-lab aims to reinforce local existing technology and know-how nuclei by building upon local embeddedness and enabling digitization of existing products, technologies, skills and institutions, complementing existing functioning ones. This type of "open factory" also occurs in other districts such as the furniture district in Marche, Italy. As Pagano et al. (2020) report, promoting direct contact on site with front-runner firms is perceived as a tool for pursuing knowledge contamination and attracting furniture producers and small firms having limited IT and technological capabilities. Similarly, in the Marche furniture district, the leading collective actors are the local Industrial Business Association and the innovation hub named *Cluster Marche.*

The leading role of AIJU, as a collective actor, is of paramount importance. Collective actors, through demonstration technology projects, living-labs orchestrators and other programs, not only create and develop knowledge but disseminate it and serve as demonstration hubs for partners. In districts like the *Toy Valley*, collective actors also represent the shared understanding and the collective mindset of the district, because they shape the norms, rules and other components of the institutional environment in an important way. Collective actors may act as supporting institutions, developing a function of brokerage on clusters, fostering innovation by acting as mediators and facilitators to diffuse knowledge within clusters, connecting the local parts or connecting the cluster to external knowledge (e.g. Mesquita, 2007). As Pagano et al. (2020) points out, these "open factories" or collective projects represent a type of "organized buzz," being a deliberate and planned attempt to foster interaction among the members of the system (firms, institutions, universities, etc.). Despite being collective actors the enabling actors' knowledge creation is based on knowledge recombination from participants' interactions, testing, trial-and-error and learning by doing in the collective project. Thus, the project

signals that change is coming to the industry and utilizes innovative firms and local managers to facilitate transition and change, promoting emulation by other local firms. Our study presents a real example of a joint project for collective learning through a collective project, contributing also to the *collective learning* topic within the cluster and industrial district literature (e.g. Keeble & Wilkinson, 1999; Staber, 2009). As the literature suggests, most of the collective learning in clusters occurs through imitation, that is, firms learn from each other based on observation, as Staber (2009) points out.

All in all, these collective actors are agents that can lead and activate place-based policies that are built upon endogenous initiatives that consider the local context, its institutions and the existing cooperation-competition dimension. Place-based policies, similar to what Bailey et al. (2018) or Feldman and Lowe (2018) posit about effective policies, need to be bottom-up, endogenous and the result of negotiations, adaptations and incremental changes in response to changing conditions, being formulated upon creative actions and collective decisions that take into account local social conditions and the interactions of actors in the policy. Thus, the involvement of all the different stakeholders and their participation in the decision-making process, also permits implication and engagement in the solution process, reinforcing collaboration and strengthening the different yet related views and perspectives to solve problems and learn.

Overall, we posit that technology transitions in MIDs, such as Industry 4.0, can be supported and led by collective actors and place-based endogenous innovation policies, contributing to open a new research avenue in MIDs literature.

The paper is not free from limitations, as it is specifically focused on a mature district in Spain that may differ from others. For future research, more experiences of digitizing districts, through different policies, would enrich literature.

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