Abstract

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The positive leverage of isomorphism: endogenous collective action for transition into Industry 4.0 in industrial districts

Abstract:
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1. INTRODUCTION

Industry 4.0 encompasses changes in industrial and organizational activities, processes, and capabilities in order to seize opportunities from the new digital paradigm, impacting directly to existent products, services, innovation processes and business models (e.g. Rindfleisch et al., 2017). Despite pioneering efforts on developing conceptualizations and logics of Industry 4.0 in the innovation community (e.g. Müller et al., 2018), its practical application to the industrial clusters\(^1\) concept, its logic and theorizing are almost absent. This digitization, and its impact on regions and clusters, remains overlooked in the literature, and constitutes this study’s goal. How does an industrial cluster transit collectively to the adoption of new radical changes brought about by Industry 4.0? This is the fundamental research question leading this study. Due to the novelty of the phenomenon, theory and frameworks are being developed at the present time on an exploratory basis. The topic, therefore, constitutes an emerging research gap in the study of clusters and industrial districts, as explained below.

Due to the recent emergence of the topic, we present an exploratory study encompassing the concept, main features and conceptualizations of Industry 4.0, following an innovation approach from which to theorize on difficulties for clusters to transit when facing radical changes and contextualizing the argumentation on traditional MIDs. For this purpose, first, we position that phenomenon in clusters, our unit of analysis, by drawing on theoretical frameworks of innovation (e.g. Robertson and Langlois, 1995; Eisengerich et al., 2010; Hervas-Oliver et al., 2018a) and isomorphism (DiMaggio and Powell, 1983; Tan et al., 2013), linked to cognitive inertia (Glasmeier, 1991), arguing that changes from Industry 4.0 present discontinuous innovation incorporating technology-distant and boundary-spanning (to the cluster theme) knowledge, a complicated combination in traditional MIDs, due to the potential lock-in driven by a strong collective identity for legitimization (e.g Gittelman, 2012; Staber and Sautter, 2011). Beyond its potential propensity toward inertia, however, we posit that institutional isomorphism and the existent social capital in MIDs is a double-sword phenomenon that can also positively constitute an enabler for fostering change on a collective-basis. In other words, the same mechanisms that can promote (negative) inertia, that is to say, too much uniformity and

\(^1\) We refer to Marshallian Industrial Districts, those socially-based socio-economic phenomena described in Becattini (1990) and others. Sometimes, however, we use interchangeably the concept of cluster but always referring to MIDs.
lack of heterogeneity, can also, with the proper policies and collective actions, (positively) foster change and adaptation.

Second, we introduce the potential role of collective actors and experimental place-based policies aimed at promoting change and avoiding cognitive inertia. In this case, we framework the argument assuming that the occurrence of effective policy for collective action is endogenous and inspired by social relations and creative and collective decisions, in the sense of Feldman and Lowe (2018). Third, we also introduce innovation platforms in order to address the specific physical tool\(^2\), characterized as a supply-chain platform, used for facilitating transition into digital ceramic manufacturing through demonstration events.

This study presents and analyzes the early stages of an (ongoing) experimental place-based policy aimed at facilitating a collectively-based transition towards Industry 4.0 in a traditional Marshallian Industrial District (MID). The approach is exploratory and the methodology is qualitative for building theory (Eisenhardt, 1989; Bingham and Eisenhardt, 2011), primarily based on interviews to 30 directly related stakeholders involved in a program for facilitating transition of the Castellon ceramic tile MID into Industry 4.0 during the 2017-2018 period. This experimental place-based policy action is also the pilot project of a new regional policy action (of Industry 4.0) to test that change in an entire region, Valencia, in Spain\(^3\).

The focal process is an emerging new place-based policy tool (CEBRA, *Ceramic Brain*) designed for Industry 4.0 transition in the Castellon ceramic tile (Spain) MID. The setting is chosen because it is currently undergoing a collective process of digitization, being a regional pilot project for Industry 4.0 in traditional low-tech industries and clusters. The Castellon cluster has been labelled a *Marshallian industrial district* (Hervas-Oliver and Albors-Garrigos, 2009). This characteristic makes the Castellon case different from other types of clusters (e.g. such as those from Eisengerich et al., 2010) and its existent social capital (see Hervas-Oliver et al., 2017) makes this setting well suited to our purpose. Thus, our study and method are both justified by the fact that although we observe that the study of MIDs and innovation is ubiquitous, the vast geography of MIDs in fact has

\(^2\) In the sense of Brusoni (2005)

\(^3\) In all different clusters such as footwear (Vinalopó cluster), toys and plastics (Toy Valley) and others alike.
not explained the occurrence of a place-based policy actions designed for an endogenous collective action towards Industry 4.0, at least in traditional manufacturing.

Pursuing this chain of thought, the present study contributes to the cluster literature by dissecting and building insights from an experimental place-based policy based on an endogenous and creative collective action, contributing to extending our knowledge on effective policies for developing endogenous place-based programs based on collective action and social relations to innovate (e.g. Feldman and Lowe, 2018; Magro and Wilson, 2018). The article also presents contributions to the debates on cognitive inertia and legitimization, building a new perspective on isomorphism that presents its positive leverage function in order to facilitate a collective transition to avoid lock-in, building new implications for literature on cluster and regional changes (e.g. Glasmeier, 1991; Sull, 2001; Gittelman, 2012; Staber and Sautter, 2011; Feldman and Lowe, 2018; Magro and Wilson, 2018). Finally, the paper also contributes to the socially-based agglomeration literature (e.g. Piore and Sable, 1984; Becattini, 1990; Saxenian, 1994; Belussi and Sedita, 2009; Hervas-Oliver et al., 2017) by presenting evidence of new policies and mechanisms that reinforce the socio-economic logic that drive innovation in those socio-economic concentrations.

The remainder of the paper is organized as follows. After this introduction, Section 2 addresses theoretical issues in MIDs, then Section 3 presents the case, Section 4 discusses the implications and conclusions.

2. LITERATURE REVIEW

2.1-Industry 4.0: conceptualizing and contextualizing
Following Fitzgerald et al’s, (2014) business-based definition, digital transformation of business is the “use of new digital technologies (social media, mobile, analytics or embedded devices) to enable major business improvements (such as enhancing customer experience, streamlining operations or creating new business models)”. Our paper is not focused on developing insights into specific digital technologies. Rather, our aim is to take a holistic view of digitization or Industry 4.0 from an innovation system and industrial cluster perspective. As such, there are multiple definitions of Industry 4.0,
referring to the same phenomenon but differing somewhat depending on their contextualization\textsuperscript{4}.

Generally, Industry 4.0 encompasses the digitization of manufacturing, constituting the manufacturing-dedicated digitization of business and industries. Industry 4.0 is also known as the Industrial Internet of Things and refers to a new paradigm of digital-based manufacturing and industrial inter-firm connected value (e.g., Kagermann et al., 2013). As Rindfleisch et al., (2017) point out, Industry 4.0, or the digital manufacturing transformation, encompasses changes in industrial and organizational activities, processes, and capabilities in order to seize opportunities from the new digital paradigm, impacting directly on existent products, services, innovation processes and business models (Nambisian, 2017). The concept includes different digital enabling technologies, such as the Internet of Things, Additive Manufacturing, Big Data, Artificial Intelligence, Cloud Computing, Augmented and Virtual Reality, and Blockchain, among others. Other authors emphasize the human and digital-machine interaction, such as Liao et al., (2017) that define Industry 4.0 as a concept that integrates cyber-physical systems (CPS) in industrial manufacturing, constituting the fourth Industrial Revolution in manufacturing (Liao et al., 2017). Similarly, Kagermann et al. (2013: 14) state that Industrie 4.0 will involve the technical integration of CPS within manufacturing and logistics and the use of the Internet of Things and Services in industrial processes, with implications and impacts on value creation, business models, downstream services and work organization.

2.2-Changes and MID institutional isomorphism: friends or foes?

Institutional isomorphism

Models on technology evolution posit that emergent technologies present an emergence phase where trial and error, experimentation and uncertainty are the norm, up to the creation of a dominant design that is the final technological trajectory imposed over alternative ones (e.g. Anderson and Tushman, 1990). In MIDs, however, the barrier to move from existent lock-in incumbent technologies to new paradigms is, generally, much more difficult, due to the existence of a solid collective identity (Staber and Sautter, 2011) and a strong necessity to be legitimized in order to access tacit knowledge exchanged in

\textsuperscript{4} See Liao et al., (2017) for an extensive revision of the concept.
local networks (e.g. Glasmeier, 1991; Langlois and Robertson, 1995; Hervas-Oliver and Albors-Garrigos, 2014), especially because local networks (DiMaggio and Powell, 1983; Deephouse, 1999) diffuse the organizational practices, structures and norms that are prevalent and socially accepted. In MIDs, due to the existent social capital based on trust and repetitive interactions, a collective understanding of collective goods, mental models or, as Staber and Sautter (2011) states a shared understanding of “Who we are”, is facilitated. Such a collective identity and understanding drives cluster firms’ isomorphism in order to obtain legitimacy (to access to local networks and tacit knowledge) by deploying similar industrial standards, business practices, culture and norms and thus promoting institutional isomorphism or conforming (in the sense of DiMaggio and Powell, 1983; Pfeffer and Salancik, 1978).

Strong identity, which is coherent with legitimization and conformity in the cluster, is usually understood as a barrier that prevents and constrain firms from adapting to radical changes, to the extent that it can even be conductive to what is known as lock-in cognitive inertia in clusters, as shown in many cases in the cluster literature (Glasmeier, 1991; Pouder and St. John, 1996; Sull, 2001; Martin and Sunley, 2006; Hervas-Oliver and Albors-Garrigos, 2014).

According to Hervas-Oliver et al., (2018a), in MIDs existing local networks, however, are the quintessential institutions providing the legitimacy to access tacit knowledge (Scott, 1992:16), being mainly orchestrated by leading firms in MIDs that are said to organize knowledge and networks (e.g. Lorenzoni & Lipparrini, 1999), usually avoiding radical innovation in order to maintain their status quo and their central positions in a cluster’s networks (e.g., Allarakhia & Walsh, 2011; Hervas-Oliver and Albors-Garrigos, 2014). Thus, the exchanged tacit knowledge within those networks is supported as long as it maintains leading firms’ centrality. These central actors feed the networks with knowledge and norms (Lorenzoni and Lipparrini, 1999) and establish the institutional models and norms in the organization field, provoking, along with other forces, institutional isomorphism.

What is institutional isomorphism? The local environment constrains and shapes organizations (Hawley, 1968), especially in agglomerations (e.g. Scott, 1995; Deephouse, 1999), provoking institutional isomorphism, increasing similarities among firms and lowering cluster heterogeneity (Pouder and St. John, 1996). Thus, institutional models
and norms, are diffuse and adopted upon existent mutual trust, social cooperation (and competition) and collective understandings or mindsets. These institutional forces drive homogeneity, while local firms pursuing legitimacy to access to local (tacit) knowledge also reinforce the process itself. Forces driving that homogenization are those such as industry associations, that promote cooperation and social ties, cooperation with local firms (even competitors that are used as benchmarks to imitate) and participation at local trade fairs and are thus looking for prestige and a sense of belonging to local groups; local social clubs, that promote friendship and social cohesion; sharing technology suppliers, that diffuse the same best practices among local firms, prescribing similar business practices and processes, etc. At this point, it must be assumed that institutional isomorphism does not automatically entice competitive isomorphism, as Tan et al., (2013) show, that is, cluster firms can be more or less innovative (or use different competitive strategies) depending on their network positions (e.g. Powell et al., 1996; Uzzi, 1996) or internal capabilities to innovate (e.g. Hervas-Oliver and Albors-Garrigos, 2009), a fact empirically evidenced as the existence of cluster firms’ asymmetric performance (e.g. Lee, 2018; Hervas-Oliver et al., 2018b).

As mentioned above, trust, repetitive inter-firm interactions and other social aspects make SMEs in those networks dependent on the leading knowledge-provider firm or another central actor (a research transfer office, local university, etc.). Thus, local networks tend to avoid disruptions and thus, in the long term, may promote inertia (Glasmeier, 1991; Poudre and St. John, 1996; Sull, 2001; Hervas-Oliver et al., 2018), to the extent that in MIDs gradual change is expected but not disruptions, due to the nature of their local networks and institutional conformity context (e.g. Garofoli, 1991; Robertson and Langlois, 1995; Hervas-Oliver, 2016). MIDs, therefore, mainly function and are based on continuous or incremental innovation upon existing local knowledge and, traditionally, have presented a manifested reluctance to change the lock-in incumbent technology (e.g., Glasmeier, 1991; Sull, 2001; Hervas-Oliver and Albors-Garrigos, 2014; Ostergaard & Park, 2015). In other words, local networks, through the role of central actors, are the

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5 In this study, radical innovation refers to technological discontinuities from Industry 4.0 that incorporate new knowledge that destroys the value of incumbent systems and technologies in the marketplace (Anderson & Tushman, 1990), bringing digital enablers that may replace traditional systems of production, similar to the digitization of mobile phones by Apple. The Internet of Things, along with sensors and cyber-physical systems is altering and disrupting the traditional processes, as explained in this case.
circuits where conformity occurs and institutional isomorphism is established and accepted.

**Collective identity and the positive leverage function of isomorphism**

Beyond this traditional assumption shown above, we posit that a strong identity and institutional isomorphism can also be an asset for facilitating change, as Staber and Sautter (2011) show in the Tuttlingen cluster transition to become an international trading cluster from a previous manufacturing cluster.

We argue that, with the right place-based policy, this isomorphism can adopt a positive role, facing changes, acting as a (positive) change leverage. In other words, institutional isomorphism in MIDs can be understood as a double-sword phenomenon constituting a positive leverage function enabling change on a collective-basis, beyond its usually assumed negative effect in the form of cognitive inertia. The rationale is based on the point that a sound place-based policy built upon local context and social relationships, can convert the potentially negative into a positive trigger to foster change.

How does it occur? We are not assuming that the strong identity per se is enough. Rather we posit that place-based policies can activate and capitalize on identity in order to influence collective understanding to stimulate change in a certain desired direction. Especially in MIDs, the strong convergence of business practices and the strong share mental model that stimulates imitation, due to institutional isomorphism, can drive cluster firms into a negative direction of cognitive inertia, that resists change by old lock-in mentalities (e.g. Swiss watch-making cluster in Jura, see Glasmeier, 1991); however, that convergence and conformity can also drive cluster firms in a positive direction towards a certain change, leveraging transition and catapulting firms, all together, to the new position envisioned, building a new sub-identity (in this case on Industry 4.0) that fits with the existing one and opens up to change and knowledge heterogeneity creation.

Assuming that Industry 4.0, therefore, presents discontinuous changes from technology-distant and cluster-spanning technology (IT and digital enablers) that go beyond the cluster theme, potential (negative) cognitive inertia may arise. Alternatively, the potential leverage effect of institutional isomorphism may trigger an over-reaction in the opposite (positive) new direction with a sound and place-based policy that capitalizes on local
identity and builds up a new compatible sub-identity that permits change. Who is promoting that positive change?

2.3-Collective actors, place-based innovation policies and innovation platforms
How to solve the potential cognitive inertia of the new digital technologies? Collective actors navigate between the interplay of technology and institutions, and even legitimize new industries (e.g. Aldrich and Fiol, 1994). Professional associations and/or public technology transfer offices (TTOs), among others, combine the complex layers of technology, institutions and social aspects (e.g. Van de Ven & Garud, 1993; York et al., 2016) and may constitute collective organizations that support technological transitions such as the emergence of new industries (e.g. Sine and Lee, 2009). In clusters, these collective actors also represent the shared understanding and the collective mindset of clusters, 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 knowledge⁶ (e.g. Mesquita, 2007). Also, collective actors can act as technology gatekeepers, introducing new technologies to the local domain (e.g. Bell and Albu, 1999). All in all, these collective actors are agents that can lead and activate place-based policies, as long as the latter are built upon endogenous initiatives that are based on the local context and the social relationships.

Place-based policies in this study are referred to in the sense of Wolfe and Creutzberg (2005) and Barca (2009), indicating mechanisms built upon associative structures of governance that are bottom-up, decentralized, open, consultative, facilitating coupling and coordination of actors, and including private and public stakeholders that share a collectively understanding of a territory’s strategic needs and priorities. This is similar to what Feldman and Lowe (2018) posit about effective policies that are bottom-up endogenous and the result of negotiations, adaptations and incremental changes in response to changing conditions, that are constructed upon creative actions and collective decisions that take into account local social conditions and the interactions of actors in the policy. These policies encourage, as Magro and Wilson (2018) state, that all different stakeholders bring ideas, new solutions and debate to frame and reframe the problem,

⁶ Adopting the roles of coordinators, interconnectors and gatekeepers. See Belso et al., (2018).
finding new ways of doing things based on the complementarities generated in the insights from bottom-up, collaboration policy design. 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 lenses to solve problems and learn. This collective, strategic self-reinforcing learning occurs in local communities of practices (CoP), or groups of people that share a set of problems or expertise and interact, and are based upon social practice and interactive learning, where people learn through engaging in a social practice and interactive learning, building upon the basis of collectively shared understanding of a territory’s strategic needs and priorities (Ebbekink & Arnoud Lagendijk, 2013:749).

Applicable programs or policies supported and led by collective actors are, among others, innovation platforms, defined as knowledge and innovation-oriented governance structures that result in complex systems and uncertain changes (e.g. Patrucco, 2011). Collective actors perform a brokerage role in order to regulate knowledge creation, exchange and design the architecture to coordinate actors involved (e.g. Kilelu et al., 2013), enabling the platform to work. Innovation platforms not only create and develop knowledge but disseminate it and serve as demonstration hubs for partners. Additional features, also including those that are future oriented, present a diversity of multi-actors, and are oriented to joining complementary capabilities from different actors and industries, enticing cross-fertilization of ideas and promoting joint or collective action (e.g. Uotila et al., 2012). Generally, platforms are basically referred to two perspectives that have evolved separately (see Gawer, 2014): types of markets (two-sided markets) for platform completion and technological architectures for platform innovation. The former refers to markets that involve two groups of agents interacting via platforms where one group’s benefit from joining a platform depends on the size of the other group that joins the platform (e.g. Armstrong, 2006:66). The technological architectures, from an engineering design perspective, refer to the methods of designing products and concepts and highlight specific design choices, emphasizing the product design that meet the needs of a core group of customers (e.g Weelwright and Clark, 1992) and form collections of common elements (e.g. McGrath, 1995) constituting systems of assets and interfaces sharing a common modular technological architecture from which products can be developed.
Overall, we posit that technology transitions in MIDs, such as Industry 4.0, can be supported and led by collective actors that are central in facilitating the adoption of Industry 4.0. These collective actors can entice innovative firms to engage in that transition, establishing, legitimizing, and embedding a new set of processes, practices and inter-firm arrangements for Industry 4.0 introduction in a district. These collective actors can capitalize on the MID logic of cooperation and competition and isomorphism, by developing and promoting a collective understanding of the new paradigm, building a supportive infrastructure, educating in the new technology and fostering change in order to avoid cognitive inertia.

All in all, we posit that collective actors can trigger those creative and collective actions in order to facilitate transition of a MID into Industry 4.0. These collective actors, acting as technology gatekeepers, can activate the positive leverage function of institutional isomorphism, developing a place-based policy or tool to facilitate change by driving a collective of actors (the entire MID) into Industry 4.0 by facilitating: i) A place-based endogenously constituted policy tool to promote change, by building up a new sub-identity compatible with the existent collective identity but, simultaneously, promoting and legitimizing change; ii) Co-developing the new technology and its fit into the existing innovation system; iii) Acting as a technology gatekeeper and legitimizing the new technology, and iv) Promoting the diffusion of the new technology paradigm.

3.-The Castellon ceramic tile MID and methods

3.1-A quick presentation of the MID: Castellon ceramic tile district.

Insert table 1 about here

Following Hervas-Oliver and Parrilli (2018), table 1 the main features of Castellon MID are explained in detail. Castellon (Valencia Region, Spain) ceramic tiles ID is a typical Marshallian industrial district, well-endowed with world-class public R&D organisations (Institute of Ceramic Technology, ITC), educational centres such as the local university (Universitat Jaume I), and private institutions such as trade associations (ASCER), all of which are focused on ceramic tiles. The Castellon cluster is a Marshallian ID that includes all the activities necessary for the ceramics value chain: clay processing, ceramic tile
production, frit and glaze decoration based on high-tech chemistry and ceramic equipment production and services such as logistics, design, and other related activities. It is significant to state that the industries in the cluster providing key knowledge and innovation are the frit and glaze (chemistry for tile surface decoration) and the ceramic equipment manufacturers (kilns, production lines, presses, etc.).

Castellon MID is mentioned in Porter’s (1990) seminal contribution. The Castellon frit and glaze industry is the most powerful auxiliary industry in the Castellon cluster and is the absolute world leader in the frit and glaze activity for tiles, having extensive operations in other clusters worldwide, including Sassuolo in Italy, another major European player with similar (slightly lower) figures of production and employment. Both European MIDs form a network of clusters, channeling information back and forth through their multinational companies in their respective industries co-located in both IDs (Meyer-Stamer et al., 2004; Hervas-Oliver et al., 2017). According to literature, most of the innovations produced in the world’s ceramic tiles industry have occurred through interactions between these two MIDs, and the development of each can be explained in part by the other’s support (Meyer-Stamer et al., 2004; Hervas-Oliver and Albors, 2009). A crucial part of the “innovation engine”, and the true strength of the Castellon cluster, is its systemic behaviour, exemplified by the inter-organisational interaction of the ITC (Tech Institute of Ceramics), within the Jaume I Universitat, the frit and glaze subsector and the ceramic tile producers. This mechanism of innovation dissemination is very difficult to replicate elsewhere (Meyer-Stamer et al., 2004).

Castellon’s leading firms perform operations world-wide, known also as home-grown MNEs, they were mainly spinoffs from local firms. They were SMEs that soon excelled and grew through their own strategies (different to those adopted by other local firms). Among these, they were leading groups of small SMEs and proactively influenced the local system; they were the first to reach global markets, pioneering marketing and design activities, incorporating R&D activities and, in general, undertaking the most risky

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7 The agglomeration index for Castellon is reported to be around 4.5 (450%) (See Hervas-Oliver et al., 2018a).

8 In 2014, 26 Castellon frit firms exported around 66% of their total production valued at 1.2 billion Euros, and employed around 3,400 workers (Anffecc, 2014). Five of them account for 75% of those exports, the leading group. See www.anffecc.es (http://www.anffecc.com/es/cifras-del-sector)
changes, and providing the best skilled labor to the local system (see more at Hervas-Oliver et al., 2017).

Castellon has rapidly recovered from the Great Recession that hit especially hard the construction related industries, such as ceramic coverings, being in 2018 at the same level of production as in 2007 (before the Recession started), occupying around 600 million square meters of premises, being currently the first player in terms of production in Europe. See Figure 1.

**Insert figure 1 about here**

### 3.2-Introduction to the methods

Overall, this study attempts to unfold and shed a light upon this specific phenomenon of Industry 4.0 in clusters, contributing to the geography of innovation and the cluster literature. We ask the question: How does an industrial cluster transit collectively to the adoption of the new radical changes brought by Industry 4.0?

The research design is an inductive case study about the early-stages of a place-based policy seeking to foster transition to Industry 4.0. This method is appropriate because the aim of this research is to gain an in-depth understanding of the complex dynamics that take place in an MID, and for this purpose the contextual conditions are important and we want to build a theory (e.g. Eisenhardt, 1989).

To answer the research question, we carried out an inductive case study of the design, development and application of an industrial place-based policy (CEBRA+, Ceramic Brain) composed of collective actors and a digital manufacturing platform for demonstration aimed at facilitating transition to Industry 4.0, similar to a testing pilot manufacturing platform. We analyzed it during the period 2017-2018. This period covers the early stages of the policy initiative to warn the cluster on the necessity to digitize manufacturing. In short, the objective of this platform s to i) fully develop the digital technology for ceramics production and ii) diffuse that technology to the cluster. We performed an analysis of reports and press releases on the platform, attended the diffusion seminars and also interviewed those collective actors and other directly-involved stakeholders, including technicians from ITC and the team of engineers at Colorker and the IT partners that were supporting the “living lab”. In total, 30 informants reported their views. In the final phase of this study, we also wanted to extend understanding on how and why innovating cluster firms could access both the collaborative innovation project
and the collective groups, interviewing also cluster firms potentially interested in attending the platform demonstration events, interviewing 7 CEOs of cluster firms interested in the events.

In table 2 collaborative stakeholders involved in the policy are detailed. See table 2.

\[\text{Insert table 2 here}\]

4.-The case study: understanding transition to Industry 4.0

4.1-A place-based innovation policy: local context and collective vision into action

The undertaking of the focal policy is the result of the Digital Agenda i4.0 launched in the Valencia Region in 2017, along with the Strategic Plan for Valencian Manufacturing (PEIV)\(^9\) as an innovation policy framework. The new turning digital tide suggested the necessity to facilitate advanced manufacturing, promoting digitization, especially in clusters. The Valencian Business and Competitiveness Regional Agency (IVACE) decided to test that potential change on the most advanced cluster in Valencia, the Castellon ceramic tile district, initiating the IMDEEA/2017/59 – CEBRA+ (Ceramic Brain) program to test a collective shift towards digitization\(^10\), using FEDER funding to support the program and promoting the formation of an ad-hoc task force or meta-organization using local collective actors and launching an innovation and demonstration manufacturing platform, along with the support of public policy representatives from IVACE\(^11\). Innovatively, that meta-organization around public and private stakeholders is bottom-up designed, following an open and multidirectional organic governance that can easily modify decisions and learn by doing. Additionally, the initiative also included two digital programs for digitizing the auxiliary industry and the distribution channel.

\(^9\) Both documents are available here (in Spanish): https://riunet.upv.es/handle/10251/107830
http://www.ivace.es/images/Industria_4.0/Agenda_Industria_40.CV_v0_web.pdf

\(^10\) http://www.colorker.com/eng/new/colorker-pioneering-industry-40

\(^11\) Task force or meta-organization in the Gulati et al., (2012) definition, as an organization whose agents are autonomous and independent, not linked by employment relationships.
(digitizing ceramic tile stores with sensors and other IoT in order to interact with final customers and retrieve information for commercial Big Data\textsuperscript{12}).

Collective actors, led by the local TTO (ITC) and supported by the trade association (ASCER), designed and set up a manufacturing demonstration platform, committed to developing, testing and eventually diffusing digital manufacturing for ceramics, by enrolling one of the most innovative companies (Colorker SA). The company was chosen because of its past cooperation agreements and pro-activity with the ITC research. The agreement of the CEBRA+ program consisted of fully developing the digitization of manufacturing tiles at Colorker, as a real testbed, financially supported by IVACE, in exchange for opening up the platform and performing demonstrations to local competitors (supervised by the ITC). ASCER, the trade association supported the program and also facilitated the creation of forums and meetings in order to diffuse the tool for a collective change. ASCER was the liaison between ITC and Colorker. The program has also been described by the world-class authoritative ceramic magazine (Ceramic World Review) as the first ceramic revolution in Industry 4.0\textsuperscript{13}. Colorker is a leading technology gatekeeper that was one of the first companies to test the digital decoration revolt that occurred in the district (Hervas-Oliver et al., 2018a), and was also the first in the cluster to introduce lean manufacturing techniques (rare in the industry) from the automotive industry. With annual growth that has remained stable at around 8% for several years, Colorker Group posted revenues of close to 60 million euros in 2017 and 65% of its sales consisted of exports mainly directed to Europe, a very dynamic indigenous SME.

In this case study, we use the concept of manufacturing demonstration platforms as a common launch pad, supply-chain based, for cluster co-operation to enable the transition to Industry 4.0 in the manufacturing process. ITC arranged the participation of the necessary firms (consulting firms from different industries, such as automotive, energy and IT), and a leading technology gatekeeper (Colorker SA) in order to introduce the Internet of Things, sensors, simulation models and other enablers for digitizing the entire production process in ceramic tile firms and making possible inter-firm connectivity throughout the supply chain, as explained in the next sub-section. Those collective actors are IVACE, primarily funding and supporting with an industrial policy program tailored

\textsuperscript{12} These are outside the scope of this paper.

\textsuperscript{13} Ceramic World Review 128/2018, pp. 12-126
to that task; the ITC, an TTO (technology transfer office) acting as leader and coordinator of the project, supplying the research infrastructure; and, ASCER, the trade association supporting and legitimizing the platform). The leading innovation firm (Colorker) acted as a “demonstrator” (competitors are welcome to have a look!) in order to show digitization advances to the rest of the industrial cluster, showing how the existent social capital allows us to navigate through cooperation and competition and how the role of collective actors makes possible the complex process of establishing, legitimizing and embedding a new set of practices and arrangements that permit us to integrate incompatible logics: cooperation and competition. The (CEBRA) platform, led by collective actors (ITC and ASCER, along with the IVACE), can be conceptualized as an evolving meta-organization, following Bawer’s (2014) and Gulati’s et al., (2012) conceptualization, integrated by autonomous agents such as collective actors, policymakers and cluster firms and IT complementors, facilitating interaction, collaboration, learning and change among all of them, and constituting a socio-economical testbed for experimentation, learning, negotiation, evaluation and reformulation of new policies. In this chain of thought, we distinguish three type of actors: (i) the collective actors, (ii) the firms and complementors of the emergent digital design (e.g. IT firms) and, (iii) the cluster firms accessing to that knowledge. In fact, it is a policy-driven tool in order to disseminate a new technology dominant design in order to collectively promote change in the industrial district.

In short, this manufacturing platform is a technological architecture that facilitates innovation, from the supply side, coordinating agents and focusing mainly on manufacturing (see more at Gawer 2014:1240-1242). Specifically, in this paper we draw ideas from platforms but specifically refer to a (real) technology infrastructure envisioned to facilitate digitization of the manufacturing process for tiles. This manufacturing platform for digital production of tiles, in its first stage is aimed at producing a tentative dominant design; it is organized and led by the leading company and its ad hoc (digital) suppliers, including complementors mainly from the IT industry. In this emerging phase, the platform is contractual-based along the supply-chain, similar to supply-chain platforms (see Brusoni, 2005), focused on developing the new processes, steps and ceramic-fit new technologies (PLCs, sensors, datamatrix codes, production software and so forth) that constitute the new digitally-based ceramic production dominant design proposed.
This platform, nevertheless, especially in its second stage (diffusing the constituting systems of assets and interfaces of the technological architecture to digitize production of ceramic tiles), turns itself into a collective action based instrument (within a given policy-mix) that builds upon social ties within a culture of cooperation and competition existent in the Castellon MID. In this second case, the demonstration (diffusion) events (collective action) take place and the purpose is to show how ceramics can be digitized. Innovation platforms share knowledge among partners (throughout the supply-chain). The innovation platform in this case, however, is designed to share knowledge among all the cluster firms. That’s the main difference! In the case of clusters, all actors have their own individual interests but a shared issue and vision, along with the assumption that cooperation is the usual way of doing business (e.g. Brusco, 1982). This collective identity, supported by the collective actors and joined together by the existent social capital, makes this innovation platform in this specific context different.

**Collective actors**

The meta-organization, formed and governed by those collective actors around the manufacturing platform, all together, promotes and reinforces the new digital logic, fostering cooperation and competition for Industry 4.0 introduction in the district, and trying to avoid cognitive inertia, which is the usual consequence of radical changes in clusters (e.g. Glasmeier, 1991). That meta-organization constitutes a policy tool to facilitate change in the face of disruptions in clusters and legitimize new paradigms that conciliate contrary forces (see York et al., 2016). In this case, collective actors are aimed at promoting awareness for change, attempting to overcome the strong character of MID functioning that is primarily rooted in non-radical changes and prone to suffer cognitive inertia and lock-in (e.g. Glasmeier, 1991; Hervas-Oliver et al., 2018), signaling the necessity to search beyond cluster themes (incumbent lock-in technologies and paradigms) and absorb external shocks.

Firms in clusters all agree that collective actors make possible the manufacturing platform for digital production of tiles and the funding obtained from regional representatives:
“The involvement of ASCER and the ITC has given legitimacy to the digital program…….(Colorker engineer).

“ASCER, was very active in promoting the change, arranging events and seminars on the topic……” (Company C).

“Yes, ASCER is preaching how important the change to digital is ….continuously…..” (Company D).

“It is clear that the ITC is playing a major role in leading the (CEBRA) project……thanks to them the implication of the Regional Government has been timely and generous…..we are acting as a block in that matter…..and this cluster presents the elements to be the one leading the change in the Valencian Region, supposedly behind the automotive cluster…..” (a Colorker engineer).

Stakeholders, such as the IVACE, agree with the fact that the Ceramic district was a good testbed for the digitization of manufacturing in the Region. Additionally, during interviews we evidenced the endogenous and bottom-up character of the policy initiative that was based on consensus by the collective actors:

As officials at IVACE stated during the interviews:

“Industry 4.0 is a nascent complex issue, as the richness of industries (from footwear to ceramic tiles, automobiles or chemistry) need to be taken into account, demanding all for specific and made-to-order digitization policies. The different degrees of concentration, historical roots and current positions, all of them demand new trial-and-error policies and instruments from which to learn from all of them. We are learning from automobiles, and then passing that knowledge on to ceramic tiles, waiting to see how new steps (footwear, plastics or furniture) can be approached. A bottom-up process and flat structure were local actors participate and suggest facilitates governance and ongoing evaluation……. All this is totally exploratory…..let’s see what happens…..” (IVACE representative).

“…the catch of this digital program is based on the fact that it is totally endogenous and bottom-up….based on trial and error and the empowerment of the cluster actors….we sought a consensus-based approach” (IVACE representative).

“Yes, since the beginning IVACE asked us what to do to digitize ceramics…..we (ITC) suggested the demonstration manufacturing platform, as a way to show the new digital technology and testing it in a real environment……also, it was important the fact that we wanted to diffuse it for local companies imitation….yes, they need to see the future….” (CEO of ITC).
“The policy has been designed by cluster actors, we (ASCER), ITC, and the IVACE agreed with the idea of the demonstration platform…we (ASCER) realized how important it could be… and we contribute as much as possible suggesting different local firms for testing the new technology…; we continuously promote events and seminars for that purpose…” (ASCER representative).

**Cooperation and diffusion**

As evidenced in the interviews, the social ties and cooperation existing in the cluster facilitate the experiment:

“The cooperation we see in this cluster, far beyond just subcontracting or arranging their own fair trade, make the perfect context in order to test the demonstration platform for 4.0… I do not think that the same pilot project can be replicated in other industries with that collective sense of cooperation….” (ASCER representative).

“For the important things, the cluster act as a block…we (ITC) have seen this before in energy, regulation and other issues….it is the social basis existent in the cluster….all of them have good relationships and trust is an important asset of this local spot…” (ITC representative)

The demonstration platform case was presented in QUALICER, the world-class leading congress on manufacturing and chemistry for ceramics, in February of 2018, with 456 international attendants from the industry. Other local seminars in the cluster have also been held, mainly through 2018, counting all together more than 300 attendants from the industry.

Currently, the firm has performed 6 technical demonstrations in a rather informal way. Obviously, the digital process is under-construction and many tests and trial and error processes are implemented and corrected every day. It is just an exploratory manufacturing platform. As the technicians in charge at ITC related:

“The demonstrations are informal, there is no any contract or signature. ITC supervises them at Colorker and facilitates the visit, it is part of the agreement for developing the infrastructure there at Colorker” (ITC representative).

**Promoting awareness**

Beyond those events, the cluster has been exposed to all most important details about how to undertake the new digital process, the new knowledge being diffused through the ITC,
seminars and other meetings. The most important thing is that the platform is legitimizing change, making the cluster change to the new paradigm. This has created the necessity to change in the cluster, and that its members should think of transiting to the new paradigm:

“Yes, we agree that digitization is a must……we are also starting our own digital project based on CEBRA, …..we are not interested in showing our changes yet” (Firm A from the cluster).

“Definitively, we are enabling our production process to be digital, taking mostly the ideas from the CEBRA program...but developing in ways specifically tailored to our manufacturing capabilities and technical conditions. The most important thing is that we can visualize how to do that….in a really practical way…..”. (Firm B from the cluster)

“…..I agree with you that the program (CEBRA) has undoubtedly contributed to disseminating the digital knowledge we need.....has also sent a message to our technology suppliers that do not want to be left behind......yes, it is a way to say: you need to change, as soon as possible”. (Firm E from the cluster)

One of the most important collective actors, the ITC, comments that developing the new technology with locally-embedded and indigenous technology gatekeepers, instead of waiting for the foreign multinationals’ solutions, is better as a way of encouraging other local firms to do so, and thus activating the change through imitation.

As engineers involved in the process from the ITC point out:

“We are creating awareness, showing to the local industrial base that the digital change is possible....and showing how it can be accomplished. For this reason we are working with a very local firm, which is a way to say: all of you can do it”. (Engineer from ITC)

“....yes, we want local companies to imitate the leading ones. We expect a reaction and an imitation by the rest of the cluster, starting with the most advanced firms....Why not going all together? ” (Director of ITC)

The ITC is committed to the diffusion of technology mainly through seminars, training sessions and participation in congresses and conferences. The next challenge is the training of the labor force, a necessary step in order to introduce the technology.

“Diffusion would seriously start once the technology is ready to be utilized; so far we are just showing tools and extending the general idea of how to do it. What is more important, however, is to start to digitize labor, training them to be capable of using the new technology”. (Director of ITC)

In table 3 we show a summary of the evidenced gathered during interviews. See Table 3.
4.2- Exploring the innovation platform: into the new technology

Interviews focused on the technical aspect of the manufacturing platform for digitizing ceramic tiles continued with the ITC and Colorker SA participants. As they commented, the ceramic tile manufacturing process may be considered a technologically mature process, from the point of view of the degree of automation, to the extent that throughout the process, products are handled automatically without human intervention of any kind. Process control and operations management, however, are managed manually, they are discontinuous and do not render production information in real time; information does not flow automatically, and the different manufacturing stages (pressing, glazing, visual inspection, in-bound logistics, maintenance, etc.) constitute isolated islands, unconnected from each other.

Despite the incipient and emerging new production plants incorporating some Industry 4.0 enablers, the cluster has a large industrial machinery park in perfect operating conditions but requiring digitalization. The idea of CEBRA is to adapt existing equipment to the new Industry 4.0 requirements, rather than just purchasing new machines and equipment. As the CEO of ITC pointed out:

“The installed ceramic equipment in the cluster is under perfect conditions to keep operating as usual…..thus, the challenge is to adapt it to the new digital requirements….working with the same machines but enabling them to generate and use digital stuff and data…this is the best recipe for the cluster…..”

(CEO of ITC).

We provide a summary of the technical conditions of the manufacturing platforms, illustrating what Industry 4.0 means in this context. Hyperconectivity of the entire production process (i.e., deploying an entire Internet of Things in the manufacturing process of the factory) was carried out by incorporating new communication ports to facilitate acquisition of the process information generated in each stage, then adapting external transducers that sent information in each machine (kilns, dryers, etc.) and finally replacing the PLCs of the different machines and equipment responsible for conveying standardized industrial communication protocols. In addition, the system was equipped with a central controller with the ability to manage information from the entire PLC network and centralize all this information in PCs. To enable correct data transmission, a
new industrial optical fiber communications network was incorporated to connect the different production sections of the factory. In order to guarantee the cyber-security of the transformed industrial environment, this industrial network was designed so that there was only one access point from the external network, at which point information traffic was controlled by a specially dedicated firewall. Then, in order to track production, the option most adapted to the needs of the ceramic process was identified using two-dimensional Data-Matrix (DM) codes on the back of manufactured tiles (a code, similar to the QR ones). The detection cameras were located under the manufacturing lines, with a compressed air cleaning system installed in zones with the greatest tendency to become dirty. Each camera was connected to the industrial network, so that management of the cameras and of the information generated was carried out from the central server.

Thus, each tile under production, has a unique code that transmit information through the system, indicating clearly its information in terms of humidity, strength, color, …… The system, through cameras that capture the unique code of each tile, record in a set of databases the exact moment at which each tile crossed a certain point in the manufacturing line. It was thus subsequently possible to determine the process conditions as well as the rest of the operational events taking place at the exact moment at which the tile was processed.

To achieve industrial integration of all data from the plant, a computer server was configured, used exclusively for industrial data management. The Nexus-Integra tool, developed and marketed by NEXUS INTEGRA, an IT partner for the project, was integrated into that machine. This technological platform is able to integrate production processes in a unified way, on a common basis and in a controlled and secure manner. The Nexus platform facilitates easy control over the three layers on which data flow is structured in the production area:

- Integration of equipment, sensors, production and field lines, as well as all industrial information sources.

- Optimized storage management and data consultation in real time, in a controlled manner on Big Data services.

- Presentation and business applications in continuous development for data processing, production control and/or process optimization, offering a complete response to the digital transformation process. While other possible solutions exist, the Nexus tool was
chosen, mainly for three reasons: it guarantees flexibility and scalability; it is an open platform, fully manageable by the user and it provides free interoperability free of industrial proprietary exclusivity, making it compatible with all existing information systems of the cluster plants (ERP, MES, SAP, BBDD, etc.)

The immediate benefits of these enablers for digitizing ceramic tiles are, in general, related to better production productivity, management and energetic efficiency\textsuperscript{14}: (i) real time management control; (ii) energy efficiency; (iii) data for achieving higher productivity (better control of equipment effectiveness); (iv) data analytics for advanced tools (algorithms for \textit{Simulation, Machine Learning, Digital Twin, Predictive Maintenance}, etc.); and, (v) Business Intelligence opportunities.

- Real control of production and real time: quick and easy way to display the reality of the production process in real time, based on the developed traceability system.
- Energy efficiency: detailed control of energy consumption, additionally offering a document management system to handle the information required by Standard ISO50001.
- OEE (Overall Equipment Effectiveness): detailed control over OEE metrics at each production point, offering detailed analysis regarding the causes of efficiency losses.
- Alarms and events: centralized alarm management of all production variables in an integrated manner with real-time and OEE modules.
- Data Analytics: use of standard system APIs; this management module enables linking with Machine Learning tools and advanced algorithms.
- Reports: simple practical tools to design customized reports based on MSExcel and Power Point, enabling any user to cross reference complex information using standard tools.
- Business Intelligence and Dashboards: agile and open system for the management of custom dashboards, enabling graphic display of relevant data and KPIs for the organization.

As regards labor and training, important changes are capital in the process. As the Colorker team explained, companies attempting to transit into Industry 4.0 need to absorb

\textsuperscript{14} Efficiency, Quality, Gas consumption, Electricity consumption, % of moisture content, % of bulk density, exit (from the kiln) temperature, powder consumption, C02 emissions, etc. All are indicators of manufacturing operations.
not only the new digital enablers (IoT, CPS, Big Data….) but to apply and implement them in their own manufacturing processes. For this to occur, IT systems and new training programs for the labor force and reorganizing the value system becomes crucial.

As the team of Colorker comments:

"Essentially, we have modified the traditional labor force in a ceramic tile firm. Beyond traditional ceramic technicians, under this new paradigm the company needs more industrial engineers, more IT personnel and even mathematicians and data scientists for Big Data, artificial intelligence or machine learning….it is also crucial to convince the existing labor force that these changes are for the good and for the best productivity....." (Ramon Debon, Colorker chief of Industry 4.0).

As regards the imitation of the technology, the pioneering company points out that the demonstration events are necessary but not sufficient for a firm learning about Industry 4.0. As the team of Colorker comments:

"We can show the general basis of the new process, but there are hundreds of details and nuances that are not easily observed, nor revealed and only by trial and error you can discover them….this is part of the (Colorker) competitive advantage. Our commitment is to show the general process but not to teach others how to do that……; also, each firm is somehow constrained by its own internal capabilities (the software they use for maintenance, qualification of engineers, etc.) and no matter what they see……how they use that knowledge and exploit it in a real fabrication will for sure differ from us……" (Ramon Debon, Colorker chief of Industry 4.0).

"In fact, it is very complicated to start from scratch to digitize without a good command of the automation of all processes and a good control of the IT systems……without a good IT system it is very complex to build a new digital process…….; undoubtedly, the competences and capabilities of firms transiting into Industry 4.0 determine how much and how fast they can go……but yes, watching our process is a good starting point” ..... “ (Colorker engineer).

5.-Discussion and theory building

Place-based endogenous policy, orchestrated through collective actors has been plausible, as a result of the existent institutional isomorphism, from which cooperation and social norms have favored a collective understanding and shared vision for the future. In this context, collective actors can design and coordinate local institutional context, introducing a new sub-identity, compatible with the existing one, for legitimizing and developing new knowledge to facilitate transition to Industry 4.0. Collective actors can
remove barriers to change, coordinate efforts and act as brokers of institutional and technological processes, proposing solutions, aligning stakeholders, developing a collective understanding of the new technology and facilitating the development of an institutional framework that stimulates change. This place-based policy, resulting from a bottom-up approach and facilitated by an endogenous collective reflection, led by collective actors has achieved:

- Removing institutional barriers
- Aligning interests
- Creating awareness on the necessity to change
- Fostering change and avoiding cognitive inertia
- Offering a supportive institutional environment to promote action and change
- Putting into action collective resources
- Coordinating actors throughout the value chain
- Designing the meeting of potential complementarities in the innovation platform
- Presenting and legitimizing new paradigms
- Developing a collective understanding and a real implication
- Supporting and facilitating the exploitation of cooperation-competition logic of MIDs.
- Legitimizing the platform, and its embedded technology, as the tool to change
- Selecting leading technological gatekeepers to offer a real-life test of the new technology
- Developing a common collective technological framework with modular and standard (universal) applications to use the new digital technology on all different modules and systems existent in the cluster, that is, promoting a solution based upon an open system.
- Creating institutional support to facilitate the gradual diffusion of the new technology in the cluster.

In addition, the investigation also brings new insights about the function of manufacturing and demonstration platforms that share a future-oriented common issue for the cluster, putting together incumbent complementarities with the external (to-the-cluster) knowledge necessary to re-shape the cluster technology (e.g. Patrucco, 2011). This type of demonstration platforms is supported in a social capital intensive local trust-based context that facilitates cooperation and competition. The digital manufacturing platform for demonstration, organized by collective actors can establish, legitimate, and embed a new set of processes, practices and inter-firm arrangements, capitalizing on traditional
existent cooperation and competition. In addition, the platform presents the advantage that it tests the technology in a real (fabric) environment and facilitates diffusion of the new digital paradigm.

This innovative policy-making is set within a socio-economical context, the MID, that facilitates governance, evaluation and learning. As Magro and Wilson (2018) point out, all the different stakeholders described participate, interact and exchange ideas, allowing the formation of complementarities generated in the insights from bottom-up, collaboration policy design. This participation allows knowledge and solutions to circulate in multiple to solve the issue, contextualizing problems and focusing on the specific local context. This view and understanding is similar to the one developed by Feldman and Lowe (2018), which posits that policies have to be contextualized on the local social dimensions and understood as endogenous collective actions that are the result of negotiations, adaptations and incremental changes in response to changing conditions, rather than planned and orchestrated programs. Thus, the flat and bottom-up empowered structure of the meta-organization generated, fueled by the vivid and trust-based social context of the MID, permits a governance of different stakeholders simultaneously, a continuous and ongoing evaluation of the policy and the flow of information and knowledge for assess and redesign in multiple directions, converting the evaluation process in strategic learning, in the sense of Magro and Wilson (2018). As the authors report, this place-based governance and policy resembles a “soft governance” where public and private agents create task forces in order to explore problems, bring solutions and produce an ongoing and prompt evaluation, allowing cross-function, cross-hierarchical and cross-industry teams and fostering two-way fluid directionality of information and knowledge for designing, redesigning and evaluating.

**Understanding MID: building propositions**

All in all, we integrate the insight for theory building, launching tentative propositions on the studied phenomenon. First, it is worth noticing that in this MID the high and intense social capital existent (see Hervas-Oliver et al., 2017) facilitated different ways of cooperation not only through the traditional sub-contracting flexible process usually cited in the MID literature but in the new venture creation by incumbent competitors’ joint efforts and shared capital. In this Castellon MID, during the first serious radical change brought about by the transition from the traditional kiln to the double-fired process (that
entirely altered the production process and extended the division of labor (Hervas-Oliver and Albors-Garrigos, 2014) and the second one, passing from the double-fired process to the single-fired one, incumbent competitors transit from competition to a mix of competition and cooperation. Incumbent firms created new shared (capital) ventures to occupy new stages of the division of labor, becoming equity partners in new ventures but still competing among themselves with their own individual firms. This cooperation and competition logic, traditionally found in the Castellon MID (see Hervas-Oliver et al., 2018a) has built the fundamentals from which to develop cooperation mechanisms that go beyond subcontracting and unify the district when facing disruptions or external shocks (see more in Hervas-Oliver et al., 2018a; 2017).

Insights for MIDs from results are presented as follows in two points. The first one is that the place-based policy designed builds upon the idea of cooperation and competition, taking for granted the diffusion of the new best (digital) practices for ceramic production, going from individual firm knowledge generation to collective diffusion, that is, offering a collective solution based on cooperation. The demonstration and diffusion events and the existent social networks can do a really good job that may be is not possible in another, different from MIDs, context. The creative collective action and actors have permitted us to develop a shared understanding and legitimized the new environment for change, attempting to avoid cognitive inertia by offering a reference point that goes beyond the lock-in existent technologies and paradigms.

Second, similarly and connected to the former point, the same problem of inertia or isomorphism can represent an advantage by using it for catapulting all together towards change, thus the isomorphism would be positive and the MID will take an additional tech advantage against others (at the cluster-level). The construction of the digital sub-identity, compatible with the existing one, has permitted us to capitalize on the positive leverage function of isomorphism: all together and equal but changing!

All in all, in the light of the insights presented, we proposed the following propositions:

**P1:** In MIDs institutional isomorphism may have both negative (lock-in) and positive effects when facing change.
P2: Positive institutional isomorphism can be activated through sound place-based policy in order to accelerate change in MIDs, thus avoiding cognitive inertia.

P3: In MDIs collective actors can legitimate change by incorporating new technologies in the collective and share understanding, creating new sub-identities compatible with reinforcing existent identity and promoting change, simultaneously.

P4: Place-based policies adapted to local context can capitalize on MID social mechanisms in order to facilitate change.

6.-Findings and Conclusions
This study has explored the first stages of an experimental place-based policy to foster transition into digital manufacturing or Industry 4.0, pursuing collective adaptation of a MID to Industry 4.0. Specifically, the role of collective actors, implemented through a digital manufacturing platform for demonstration, is analyzed in its early stages of development, during 2017-2018.

Through an inductive and qualitative study of the on-going Castellon ceramic tile MID transition towards Industry 4.0, this study contributes to the literature of Industry 4.0 and MIDs by dissecting an (on-going) real case of collective cluster-based application of Industry 4.0, using the frameworks of (i) innovation and institutional isomorphism, (ii) collective actors and place-based policy, and (iii) innovation platforms.

How does an industrial cluster transit collectively to the adoption of the new radical changes brought about by Industry 4.0? In order to answer, we carried out an inductive case study of the design, development and application of an ad hoc experimental place-based policy, based on a creative collective action co-governed by local collective actors and public representatives, and orchestrated through a digital manufacturing platform. The results have presented contributions and knowledge extensions on place-based policies built upon collective action and social relations (e.g. Feldman and Lowe, 2018).

The study has also presented advances for the debate on isomorphism and legitimization, building a new perspective on institutional isomorphism that presents its positive leverage function in order to facilitate a collective transition, avoiding stagnation due to non-digitization, through capitalizing on local isomorphism but building a new (digital) sub-identity. Last but not least, the study’s insights also contribute to the socially-based
agglomeration or Marshallian literature (e.g. Piore and Sable, 1984; Becattini, 1990; Saxenian, 1994; Belussi and Sedita, 2009; Hervas-Oliver et al., 2017) by presenting tools in order to facilitate change upon cooperation and competition endowment, underpinned by a high local component of social capital, one of the cornerstones of the MID concept.

Overall, this study has presented useful insights and implications from which to help practitioners, cluster managers, CEOs and policymakers to facilitate collective transitions into Industry 4.0. Implications extend the repository of industrial policy knowledge in order to make clusters more competitive and well-functioning (e.g. Eisengerich et al., 2010) through the development of endogenous place-based policies based on collective action (e.g. Feldman and Lowe, 2018). Additionally, results also contribute to the SME literature, by presenting collective alternatives from which to facilitate SMEs change, that usually present a technology-based deficit to absorb new technologies (Hervas-Oliver et al., 2014), as long as the nascent research on Industry 4.0 has been extensively based on large corporations (e.g. Müller et al., 2017) and less on small business (e.g. Kagermann et al., 2013).

The paper presents limitations. First, the implications are based on particular MID, results that may not always be replicated in other districts or clusters. Second, the analysis is contextualized as an on-going (incomplete) innovation policy initiative. For future studies it is necessary to understand how Industry 4.0 impacts firms’ performance and what are the drivers or firms’ internal capabilities for enabling the access to and use of that technology.

References


# TABLES AND FIGURES

Table 1-Overview of Castellon tile district

<table>
<thead>
<tr>
<th>Variables</th>
<th>Castellon (Spain, Valencia Region)</th>
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<tbody>
<tr>
<td><strong>Product</strong></td>
<td>Generally, red-clay ceramic tile as leading product in medium and medium-low markets; special emphasis on wall tile.</td>
</tr>
</tbody>
</table>
| **Firms and employees**                | Around 130 tile firms in 2018 (300 in total, counting auxiliary industry); around 220 tile firms in 2006 (400 counting auxiliary industry; after 2007 Great Recession and concentration of the industry)  
20,000 employees in 2018, around 30,000 in 2006  
Production of 550 million of square meters in 2017, around 600 in 2006  
Traditionally SMEs firms (co-existing with multinationals, both foreign and indigenous) |
| **Export intensity and markets**       | 80% of exports in 2017 (70% in 2018, as national market rebounds)  
First European producer and second most export-led cluster in relative terms as % of production  
Main markets are Europe, Asia and USA (France, USA, UK or Israel, among the top). Around 50% to Europe, 24% Asia and 14% USA |
| **Local firms**                        | Presence of leading home-grown MNEs very innovative in both product and process, undertaking all activities: manufacturing, innovation, marketing, R&D, etc. |
| **Supporting industries**              | Very powerful chemical ceramics (for ceramic tile decoration) companies, world-class leading industry multi-located in Asia, America, Europe and North Africa. Includes the presence of leading Sassuolo mechanical (kilns and production-oriented) firms. |
| **Local institutions**                 | Very comprehensive array of local institutions: R&D centre (ITC), local university focused on engineering for ceramics (UJI), powerful trade associations (ASCER), etc. ITC is the leading ceramic R&D centre in the world. QUALICER world-class congress on manufacturing/chemistry for ceramics |
| **Major recent transformations**       | Castellon always connected to Sassuolo, leading the latest digital transformation to inkjet tile decoration. Still focused on manufacturing and innovation, providing world-class knowledge on tile decoration to the rest of clusters worldwide. Venue for the most important patents in tile decoration. |
| **Major activities/capabilities**      | All of them: clay mining, refining and atomizing; tile manufacturing, including pressing, decoration (chemical) and burning in kilns; machinery and equipment provision and repair; especially relevant the production of frits and glazes (chemical components) for tile decoration. Design, marketing, logistics, all focused on tiles.  
Home-grown MNEs, mainly from the chemical tile activity, present in all clusters worldwide., such as Esmalglas, Torrecid, Ferro, Coloronda, Esmalfrit, Kerafrit, Fritta, Kerajet, etc15  
Very extensive social capital because of historical matters, with extensive reports on cooperation (see Hervas-Oliver et al., 2017) |

Source: own elaboration, based on Ascer and Assopiastrelle, and Hervas-Oliver and Albors-Garrigos (2007); Hervas-Oliver and Parrilli, 2018; and PEIV (2018).

15 http://www.anffecc.com/es/empresas
Figure 1 Production evolution in both MIDs (in million square meters): Castellon and Sassuolo

![Production: Castellon and Sassuolo](image)

Source: ASCER (ES) and Confindustria Ceramic (IT); 2018 is a prediction.

Table 2 Participants in the interviews

<table>
<thead>
<tr>
<th></th>
<th>Colorker</th>
<th>IVACE</th>
<th>ITC</th>
<th>ASCER</th>
<th>IT companies supporting</th>
<th>Cluster companies engaging</th>
<th>Total actors</th>
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<tr>
<td>Engineers and top executives</td>
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<td>Officials and representatives</td>
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<td>CEOs*</td>
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<td>3</td>
<td>5</td>
<td>6</td>
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*not involved, but cluster firms participating in interviews as users or interested on the manufacturing platform in the second stage of diffusion.
Table 3. Summary of main points evidenced during interviews

<table>
<thead>
<tr>
<th>Issues</th>
<th>Evidence</th>
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| Collective actors | • “The involvement of ASCER and the ITC has given legitimacy to the digital program”  
• “ASCER, was very active in promoting the change, arranging events and seminars on the topic”  
• “Yes, ASCER is preaching how important the change to digital is…..continuously”  
• “It is clear that the ITC is playing a major role in leading the (CEBRA) project……thanks to them the implication of the Regional Government has been timely and generous” |
| Endogenous and bottom-up collective creative policy | • “A bottom-up process and flat structure were local actors participate and suggest facilitates governance and ongoing evaluation……. All this is totally exploratory”  
• “the catch of this digital program is based on the fact that it is totally endogenous and bottom-up….based on trial and error and the empowerment of the cluster actors….we sought a consensus-based approach”  
• The policy has been designed by cluster actors, we (ASCER), ITC, and the IVACE agreed with the idea of the demonstration platform….. |
| Cooperation in the MID | • “The cooperation we see in this cluster, far beyond just subcontracting or arranging their own fair trade, make the perfect context in order to test the demonstration platform for 4.0”  
• “For the important things, the cluster act as a block....” |
| Diffusion to avoid inertia | • “..also, it was important the fact that we wanted to diffuse it for local companies imitation….yes, they need to see the future....”  
• “...we continuously promote events and seminars for that purpose...” (ASCER representative). |
| Promoting awareness and change on the cluster | • “Yes, we agree that digitization is a must…….”  
• “… taking mostly the ideas from the CEBRA program…but developing in ways specifically tailored to our manufacturing capabilities and technical conditions. The most important thing is that we can visualize how to do that….in a really practical way.....”  
• “.....I agree with you that the program (CEBRA) ....it is a way to say: you need to change, as soon as possible”  
• “We are creating awareness, showing to the local industrial base that the digital change is possible….and showing how it can be accomplished…. is a way to say: all of you can do it”.  
• “....yes, we want local companies to imitate the leading ones. We expect a reaction and an imitation by the rest of the cluster, starting with the most advanced firms....Why not going all together?”  
• “we are just showing tools and extending the general idea of how to do it” |

Source: own, based on the summary of interviews.