

Regional Industrial Policy for the Manufacturing Revolution: Enabling Conditions for Complex Transformations.

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Abstract

In this paper, we argue that regional industrial policy has a key role to spur socio-economic development. Industrial policy promotes structural changes, which are rooted in productive transformation, led by the expansion of collective capabilities. Today both globalisation and the fourth industrial revolution are inducing substantial structural changes, which regional industrial policy can favour and orientate. Our analysis is rooted in complex system theory, highlighting four main elements of regional industrial policy, that provide enabling conditions for the adaptation and evolution of the regional system. These arguments are illustrated in the case of the Emilia Romagna region in Italy.

Keywords: industrial policy, regional development, structural changes, complex systems

JEL Codes: R11, L52, L23.

Introduction

Industries are experiencing deep structural changes nowadays, primarily as a result of Industry 4.0, namely the numerous and converging technological innovations in various scientific fields that contribute to what has been called the fourth industrial revolution (Bailey et al., 2018; De Propris, 2018; Bianchi and Labory, 2018a). Industrial transformations in times of industrial revolutions are unpredictable and non-linear, i.e. complex, which makes policy difficult to design. In addition, industries can be argued to be constantly evolving, introducing innovations of various kinds and adapting to changes in the competitive context. Hence, the design of policy for promoting structural changes, namely industrial policy, has to take complexity into account.

Another aspect of this complexity is that industries are not isolated systems. When firms grow, upgrade their production, branch into new activities, adopt new production systems, the whole socio-eco system is affected. New skills and also new jobs might be required, with impact on working conditions and income, training and education, hence the society. New products but also new ways of working may change individuals' culture; for instance, the smartphone is changing people's culture, allowing new ways of meeting and communicating, of accessing information and buying, of reading books and enjoying art.

Structural changes therefore have complex effects, in the sense of intertwined effects on the different parts of the socioeconomic system, which overall impact is more than the sum of the parts and may also be difficult to predict. Structural changes also depend on the characteristics of the places in which industries are embedded, and on their historical features. The definition of the 'place' is not straightforward: is it the local area, the region or the nation to which a firm or industry belong? Firms are embedded in territories, where they find the resources and capabilities necessary for their production. Even if production is organised as global value chains (GVCs), territories are important because this type of organisation is defined as production processes made of enterprises located in different places that collaborate and coordinate to realise the different phases that allow the manufacturing of the products. Firms have to develop distinctive competencies in order to take part in or build their own GVCs. For this purpose, the role of territories is important, because they can favour the development of their enterprises by providing appropriate capabilities and resources: infrastructure, capabilities and institutions that ease the adaptation of businesses. We argue that the region has an important role to play in this respect: it is close enough to individuals and communities to get understanding of their concerns and adequate information; it is generally sufficiently politically strong to influence the national political level in the design of new institutions and in the request for public funds.

While the industrial policy debate has been mainly focused at national level, a number of scholars and policy-makers have raised the issue of the governance of this policy, arguing for a strong role for other levels, particularly the regional one (Bailey et al., 2018; Bianchi and Labory, 2018b). In Europe, the proposal for place-based regional policies and the implementation of smart specialisation strategies at regional level have followed this stance (Boschma, 2015; McCann and Ortega-Argilés, 2015). Indeed, smart specialisation can be considered as an industrial policy, based on the entrepreneurial discovery process, identification of strengths and weaknesses and industrial activities so as to promote those new activities that are related to existing ones and can lead to new development paths for the regional economy.

This paper contributes to the literature in two major ways. First, it argues that the design of industrial policy can gain important insights from the Evolutionary Economic Geography (EEG) framework, and particularly the complexity approach defined within this framework, viewing regions as complex adaptive systems, and industries as their subsystems. The literature on industrial policy has mainly been empirical, discussing experiences of industrial policy or proposing elements that industrial policy should comprise (Rodrik, 2004, 2008; Cimoli et al., 2009; O’Sullivan et al., 2013; Bailey et al., 2010; Andreoni, 2016; Bianchi and Labory, 2006, 2011, 2018a, b). It lacks a unified theoretical framework, since different instruments are discussed in specific theoretical approaches, for instance innovation policy instruments in the evolutionary approach, antitrust issues in neoclassical analysis of market structure. However, different types of instruments are implemented together (support to innovation, support to SMEs, territorial infrastructure, fair competition on markets), as sets aimed at promoting the structural changes of industries. A joint consideration of these instruments is therefore necessary, in order to guarantee coherence.

Second, this paper examines a particular experience of definition and implementation of industrial policy, thereby proposing a contribution to the EEG literature where the lack of discussion of public policies for the resilience of regions or the orientation of regional growth or development paths has been highlighted. More precisely, the EEG framework has been blamed for focusing attention on the role of structure and emerging patterns in explaining regional development, and not enough on agency (Martin and Sunley, 2015; Bristow and Healy, 2014a, b; Hodgson, 2009), namely the role of the behaviour of individuals belonging to the system, as well as their collective actions, especially the role of institutions and government policy.

The industrial policy designed and implemented by the Emilia Romagna (ER) region in Italy was explicitly aimed at favouring the adaptation of the regional system to the manufacturing revolution, starting with a fundamental element and driver of development, namely industries. It has specific features that resonates with the EEG literature and complexity perspective, which this paper examines, drawing conclusions on the importance of regional industrial policy.

Data were collected for this paper on the basis of interviews with regional stakeholders, in the government, regional administration, as well as businesses, business representatives, worker unions, and education institutions (school and universities). Official documents produced by the stakeholders, particularly the policy documents of the regional government were also reviewed and analysed.

This paper is organised as follows. Section 2 reviews the theoretical framework proposed by the EEG in the analysis of the long-term evolution of regions, particularly the complexity approach which is shown to be useful to provide a background for complex regional industrial policies. Section 3 presents the case study: the reasons for the new industrial policy defined in the ER region in 2015 (3.1.), a brief history of industrial policy in the region (3.2.), and the current industrial policy (3.3.). The last section concludes on the scope for defining and implementing such complex industrial policies in other regions, and highlights limits and insights for future research.

EEG and complexity

The emerging field of evolutionary economic geography (EEG) has been fed by numerous studies and reflections in the last decades. According to Boschma and Martin (2007), EEG is concerned with the spatialities of economic novelty (innovations, new firms, new industries, new networks), with the emergence of spatial structures from the micro-behaviours of economic agents (individuals, firms, organisations); with the capacity for self-organisation, even in the absence central coordination or direction; and with the interaction of path creation and path dependence processes that shape geographies of economic development and transformation. The assumption is that economic transformation proceeds differently across spaces, due to a number of factors, including path dependency, the characteristics of their economic structure, of agents and institutions.

Boschma and Martin (2010) and MacKinnon et al. (2009) suggest that EEG comprises three major approaches, that are interrelated and complementary, but each present a different point of departure. The first approach, based on Neo-Darwinism or Generalized Darwinism, uses evolutionary concepts such as variation, selection and retention to explain why some evolutionary paths are successful and others not (Essletzbichler & Rigby, 2007). The second approach is focused on path-dependency and shows how history influences development through concepts of contingency, self-reinforcing dynamics and lock-ins (Halkier, 2014). The third approach has a complexity perspective and stresses that systemic interactions in the economy drive the emergence of non-linear patterns of change, through self-organization, emergence and co-evolution (Martin & Sunley, 2007). We argue that this third approach is useful for the design and implementation of industrial policy aiming at promoting structural changes. The major reason is that industrial development is a complex process, that influences and is influenced by the social, cultural and political sphere as well as the purely economic sphere (Bianchi and Labory, 2019).

Complex industrial policy is required when industries and regions are considered as complex adaptive systems. Regions are made of numerous interacting elements (individuals, communities, firms, social organisations, institutions, and so on), which individually and collectively generate learning processes and adaptation, especially in response to changes in their environment, with which they strongly interact (other regions in the same country, foreign firms and institutions of various types). Regions' adaptation results from the interaction of the actions of the individuals present in the region. The cumulative effects of these individual actions generate patterns that create structural change and adaptation (Martin and Sunley, 2007). However, we argue that regional adaptation not only results from the interaction of individual actions, but also the interaction of the actions and adaptation of sub-systems comprised in the region. Industries are such sub-systems, made of connected and interacting entities, namely businesses, consumers, suppliers, as well as cultural, legal and political institutions; they belong to wider systems, generally with linkages and interactions that go beyond this territory. They are influenced by the actions and emerging patterns of the wider systems they belong to, be they regional or national, and they also influence the patterns emerging in the wider systems. As their environment changes, due to changes in market conditions or the appearance of new technologies or other innovations, entrepreneurs react and adapt (Martin and Sunley, 2007), and their complex interactions generate new spatial structures, that can be self-organising but also influenced by an intentional collective action such as industrial policy.

The adaptation of individuals parts and of subsystems are the sources of uncertainty and unpredictability of the adaptation and evolution of the regional complex system, which can only be understood by analysing the interactions between individuals and subsystems. The latter are governed by institutions, which stimulate certain forms of interactions and constrain others (Hodgson, 2006). In turn, the characteristics of institutions results from the regional interactions they govern (Cumbers et al., 2003). The role of institutions in EEG has been extensively discussed (MacKinnon et al., 2009; Hodgson, 2009; Boschma and Frenken, 2009). From a complexity perspective, institutional change plays a key role in regional development, by constraining and enabling individual actions.

In times of deep and constant structural changes, the question arises as to how can the adaptation of industries be promoted. Given that industries are systems embedded in wider systems, it appears that only a complex policy can be effective in this sense. Hirschman (1958) after all suggested that a good development policy could only 'complexify' the economy, namely consider it in all its complexity, rather than simplifying it.

The role of policy in the adaptation of regions does not seem to have been extensively discussed. Thus, Martin and Sunley (2007) outline a limit of complexity thinking that is shared by evolutionary ideas, namely that it portrays "human agents as mainly adapting to their environments rather than actively making these environments" (Martin and Sunley, 2007, p. 591). Bristow and Healy (2014a), in their analysis of regional resilience, emphasise that the analysis of the role of human agency in the evolution of regional systems is key to their understanding, although the literature has focused on the role of structure. This is also what distinguishes socio-economic systems from biological ones. Human agency involves different aspects, one of which is the role of governments and their policy in influencing the development paths of regional systems. Bristow and Healy (2014a) propose three aspects to consider in order to understand how agency influences the evolution of system: how individual behaviour adapts and change (acquisition of knowledge, learning process, adaptation), how they translate into collective decisions and effects, through interactions in social networks, communities and government) and how collective rules and governance systems constrain and enable evolution (institutional structures of governance, political power).

The complexity perspective sees the social system as complex and adaptive, developing multiple endogenous control mechanisms that make it work, and which are continually evolving over time. The government is just one component of those endogenously evolved control mechanisms. In this context, the government cannot control the system, but it can influence it (Colander and Kupers, 2014). In other words, the government can act as a catalyst of changes towards desirable paths, avoiding lock-ins and favouring learning processes.

Complexity science has stressed the importance of enabling conditions or infrastructures for particular patterns to emerge in systems (Russ, 2006; Mittleton-Kelly, 2003). For Mittleton-Kelly (2003), the enabling infrastructure of organisations as systems comprises the socio-cultural and technical conditions that facilitate the emergence of new organisational forms, by encouraging self-organisation and the exploration of the space of possibilities, namely respectively the emergence of new patterns and the access to new knowledge activating learning processes. Another enabling condition for organisational change is the control of inhibitors, such as differing perceptions between organisational members that may lead to conflicts that impede evolution, or lack of information and competencies.

Similarly, we argue that industrial policy aimed at favouring structural changes in the region should focus on providing the enabling conditions for the regional system to evolve and adapt along preferred development paths. Bianchi and Labory (2018b) review both the literature on industrial policy and concrete experiences of regional industrial policies undertaken in different countries, and conclude that the most successful ones share a number of common elements: capabilities (providing the conditions for the development of capabilities, especially innovative capabilities), networking for the building of complementarities (both internal and external to the region), participative governance (involving stakeholders in the policy process in order to better access to relevant information and share a vision and common strategies, so that the whole regional ecosystem is mobilised towards the agreed aims), and policy coherence, between the different policy fields that are interdependent, namely industrial, social, educational, trade, energy and so on, and between the levels of government in the policy process, namely local, regional, national and supranational. These are precisely the conditions enabling evolution and adaptation of the regional complex system.

Capabilities, namely knowledge and competencies, human capital and research capacity, as well as appropriate infrastructure and institutions, are essential to encourage self-organisation and the exploration of the space of possibilities, particularly accessing new knowledge and initiating learning processes to enable for instance the adoption of new technologies and the branching of new activities in industries. For instance, connectivity is key for information and knowledge to be exchanged and processed, and collectively created. In addition, capabilities of individual agents and organisations are also important. One is the ability to learn new knowledge, depending on absorptive capacity that has been widely discussed in the economic literature (Cohen and Levinthal, 1990). In industries, capabilities depend on access to finance, the availability of R&D labs and skills, communication and transport infrastructure, etc.

Policy actions aimed at favouring networking within and outside the region also appear to be essential for regional innovation and the emergence of new specialisations (McCann and Ortega-Argilés, 2015; Boschma, 2015, Trippel et al.; 2015). Within the region, they allow to exchange knowledge and competencies for higher knowledge creation and transformation of innovation into industrial applications and commercial success. This networking arises at all levels: between businesses, administrations, universities and research centres, and across different types of institutions. It enables the identification of competencies and potential cross-fertilisations, across sectors and across institutions, such as for instance between research institutions and businesses. Networking aims at strengthening interactions between the entities of the complex adaptive system, and between the entities and their environment, which have been shown by complexity scientists to be essential for the complex system to successfully evolve and adapt (Colander and Kupers, 2014).

The governance of the policy process is also important to favour the exploration of alternatives, choosing solutions and supporting a specific new order to be established. For this purpose, knowledge of a territory's activities, specialisations, as well as strengths and weaknesses is necessary. This means a large amount of information must be collected and processed in order to make appropriate decisions. This makes the regional level more appropriate for the definition and implementation of industrial policy. At that level, the necessary information and knowledge that have to be collected and processed are neither too large (as at national level) nor too small (the identification of new development path requires sufficient variety and diversity of information and knowledge). In addition, the regional level confers a reasonable level of proximity for knowledge communication and creation, at geographical, cognitive levels (Boschma, 2005).

This does not mean that there is no role for the national level. Enabling conditions are provided at regional level, precisely responding to the specificities of the region, but the national level has an important role in providing framework conditions (regulation and antitrust, contract law, and so on) and favouring synergies between regions, between the different parts of the national system. The national level of government should also contribute to the coherence of the whole system.

In addition, the large amount of information and knowledge that have to be collected and processed imply that governance has to be participative, including all regional stakeholders in the policy process. In this manner policy-makers can collect sufficient information and develop learning and understanding about possible paths only if they interact with local stakeholders. This is also important because adaptation and evolution of only a limited number of the system's members means that the system breaks into different parts, dividing those which adapt and those which do not. For the whole system to adapt all parts must contribute. Participative governance allows policy-makers to access relevant information and knowledge, identify possible development paths and make vision and choices that can be shared among all regional stakeholders, so that all the system is mobilised towards the chosen aims. Such participative governance processes have been outlined as essential for the success of policies in the case of resilience to shocks like disasters or economic crisis (Bristow and Healy, 2014a, b, on regional resilience; Alexander, 2010; Özerdem and Jacoby, 2006, on resilience to disasters), because they favour the emergence of bottom-up adjustment processes, which are essential for the adaptation of systems (Colander and Kupers, 2014). In this sense, the regional industrial policy proposed in this paper is a policy for resilience.

Another important element of industrial policy for structural change concerns policy coherence, both in the multi-level governance framework and between policy fields. The former regards the different roles of the local, regional, national and supranational policy levels. While industrial policy should be defined and implemented primarily at regional level, the actions and instruments it consists of have to be coherent with the national ones. In addition, coherence between policy fields must be ensured. Industrial development is multi-dimensional and requires actions in different fields, ranging from traditional innovation policy (R&D subsidies, support to new firm creation and to technological transfer, etc.) to social policy (favouring the participation in the labour force, training and education to adapt skills, etc.), energy policy (access to low-cost energy is important for business competitiveness) and other policy fields. The example of the Emilia Romagna region below illustrates how such a coherence can be favoured.

Overall, we can summarise the four main enabling conditions of regional industrial policy for adaptation and evolution as follows:

1. capabilities: R&D investment, skills, university – industry links, infrastructure (communication, energy, transport);
2. Networking: between all actors in the regional system, namely firms, university, research centres, educational institutions, etc., both within and outside the region;
3. Governance: has to be participative;
4. Coherence: between policy levels and between policy areas.

These four conditions combine to favour structural change in the region along specific growth paths, possibly through the development of new specialisations. In fact, this complex regional industrial policy is a policy for smart specialisation, based on the emergence of new industries or the branching of new activities from existing ones. At regional level, the smart specialisation strategy has been defined as a place-based industrial policy (Foray, 2013, 2015). The participative governance favours the 'entrepreneurial discovery process', while networking for complementarities favours the exploitation of related variety. The concept of related variety was proposed by Frenken et al. (2007), who argued that: "one expects knowledge spillovers within the region to occur primarily among related sectors, and only to a limited extent among unrelated sectors" (p. 688). Variety in terms of industrial sectors – industrial diversification – increases adaptation of the regional system since the potential damage of a sector-specific shock is much lower (there are many other sectors present in the region that will not be affected by the shock) than when the region is specialised in a specific sector. The probability of sector-specific shock is higher in a diversified region (there are many sectors) but the potential damage is much lower (the damaged sector is one among many others). In the long-term, a specialised region has less capacity for adaptation since it has few activities from which the new sector can branch out, so that there are few recombinatory options available. Diversified regions have more possibilities for recombinatory options, larger available knowledge base, but new combinations and new sectors will not develop unless there are potential overlaps and combinations between the different knowledge bases. In other words, related variety is necessary to create the potential for learning and for the creation of new sectors from existing knowledge bases. Unrelated variety may also lead to adaptability but only if radical innovations occur, with technological breakthrough (Castaldi et al., 2014).

The next section illustrates regional industrial policy based on the above four enabling conditions, in the case of the ER region.

Complex regional industrial policy: providing enabling conditions in the Emilia Romagna Region

Regional industrial policy in times of manufacturing revolution

The above discussion has highlighted that the regional government might have a role in favouring particular growth path in the region, by providing enabling conditions for the evolution and adaptation of the regional system. In general, complex systems adapts to changes in their environment, with which they strongly interact. Evolution may also be caused by the change in a part of the system. Applied to the region, in both cases industrial policy may be focused on helping the system co-evolve with the environment, in which policy is pro-active, trying to anticipate changes so as to prepare the regional system for changes. Alternatively, industrial policy may be reactive, if defined and implemented after the change in the environment has occurred, or after a shock. Unexpected shocks can only be faced by reactive policy; however, structural changes are very long-term processes so that they are better addressed in pro-active policies, that start to provide new capabilities and other enabling conditions early.

The ER region was recently confronted with both types of situation. On the one hand, an earthquake arose in 2012, affecting the industrial core of the regions, and the regional government had to rapidly react to face the emergency and rebuild particularly the industrial

areas, so that the economic activities would not be too affected and so that people could return to work and normal life (Bianchi and Labory, 2014). On the other hand, the regional authorities and stakeholders started to reflect on changes in the competitive context, and particularly Industry 4.0, for which it was felt that a pro-active policy was required, in order to prepare the regional system for the deep changes, so as to ensure simultaneously economic development and social cohesion, namely avoiding the social fragmentation that industrial revolutions often imply (Bianchi and Labory, 2018a).

Industry 4.0 is characterised by numerous and important technological developments in many scientific fields, such as biotechnologies, nanotechnologies, artificial intelligence, robotics and big data analytics, many of which are converging, thereby offering the opportunity to develop new processes and new products. New businesses are emerging, old ones are changing (for instance, the automobile industry has new production process and new competitors, producing self-driving cars), and new market intermediaries are also disrupting activities, such as online platforms (Bianchi and Labory, 2018a).

The ER government therefore started a reflection on these disruptions, together with regional and external stakeholders, in order to define a pro-active policy, that could help the regional system prepare and adapt to the changes. An important consideration was that production systems are changing in industries, implying changes in the global value chains that the regional firms manage or are part of. In global value chains, various firms, either located in proximity or at distance, realise the different stages of the production process (Gereffi, 1994; Sturgeon, 2008). The ER region concluded that the region has an important role to play in promoting the necessary structural changes, particularly in attracting high-value creating phases of these production systems. These phases are the pre and post manufacturing phases, namely R&D and prototype realisation on the one hand and marketing / commercialisation on the other hand. With Industry 4.0, manufacturing phases are increasingly performed by robots in smart factories, that can be located anywhere, provided there is access to energy, high capacity Internet and materials. As a consequence, territories able to pool and develop key resources for pre and post-manufacturing phases attract firms, since they provide access to infrastructure, especially for high and rapid communication, as well as low energy costs, and also innovative capacity, with highly qualified human capital and appropriate research facilities. Such territories are hubs of knowledge creation, consisting in dense networks of universities, research centres, and other.

Investment in skills is also important because the most value-creating phases of production processes are those most intensive in skills. We show below that this has been a focus of the industrial policy of the Emilia Romagna region, creating an appropriate 'milieu' or fertile ground for learning, innovations and industrial applications to emerge. In particular, with the use of robots, artificial intelligence and automation many routine and low-skilled jobs are expected to disappear. Factories using the new production system are hiring more engineers and high-level technicians who can control the system of machines. Overall, high skills, corresponding to university degrees, as well as soft skills such as communication capacity and creativity, are expecting to be the most required (Brynjolfsson and McAfee, 2015).

This has been the basis for the definition of the regional industrial policy in 2015, in line with the smart specialisation strategy of the region. Before explaining the main elements of this policy, the next section reviews the industrial policies adopted in the past.

Tradition of industrial policy in the ER region and actual performance

The Emilia Romagna region has implemented industrial policy continuously in the last decades (Bianchi and Labory, 2011). The current industrial policy follows the principles of the past, in particular the governance framework, which is democratic and participative, involving all stakeholders in the policy process in order to identify the strengths and weaknesses of the regional socio-economic systems and define policy accordingly, in the sense of favouring particular development paths. The current industrial policy is interesting in that it has been defined to prepare the region to the fourth industrial revolution, promoting its adaptation to the changing competitive context.

It has acted on the four elements of industrial policy, the main four enabling conditions that favour the regional system's adaptation and evolution. Participative governance has characterised the policy process, particularly since the 1990s, where the policy aimed at transforming the regional system to a regional innovation system was decided on the basis of a dialogue with stakeholders, institutionalised in the 'Conferenza per l'economia e il lavoro' (Conference for the Economy and Labour) meetings (Bianchi and Labory, 2011). The other three elements of enabling conditions for structural changes are also included in the current industrial policy: developing capabilities, networking for the building of complementarities and policy coherence.

Before explaining the elements, the characteristics of the regional system have to be outlined. The ER region has industrialised essentially after WWII, taking advantage of the economic boom in Italy and of its knowledge and competencies in the mechanical engineering sector. This sector indeed started in the region with a few firms in the 1930s. After WWII many SMEs were created in different sectors, many of which took advantage of the knowledge base in mechanical engineering: for instance, the packaging or biomedical sectors. The high social capital in the region favoured the creation of SME systems, or industrial districts based on labour division between the firms. The industrial districts of the region were widely studied in the 1980s and 1990s (for instance, Piore and Sabel, 1984, mention them as example of flexible specialisation).

The ER region is now among the most dynamic EU regions; its innovation system has strengthened over the last decades, and it results among the four most innovative regions in Italy (De Marchi and Grandinetti, 2016). The regional economic system is increasingly focused on international markets and it features a high rate of entrepreneurship, a strong manufacturing sector, a high level of innovation, and GDP per capita higher than the Italian and European average. The main sectors are Mechanical Engineering & Automotive, Agro-food, Housing and Construction, Fashion, Health and Wellness, Culture and Creativity and Tourism. Many of these sectors contribute to the "related variety" of the industrial structure because they have impact on all other sectors: mechanical engineering produces engines and machines for many different sectors, and culture and creativity is also transversal. Emilia-Romagna also has the highest innovation capability at national level, alongside a few other regions, according to the Regional Innovation Scoreboard (EC, 2017).

In 2018 the ER region had the highest GDP growth rate among Italian regions (1.4%), employment had increased and the unemployment rate has continuously declined in the last years, reaching 5.9% in 2018. In addition, these trends are expected to continue in the next years (Unioncamere, 2018). Regarding industrial development, industrial production has constantly increased since 2003, despite the 2012 earthquake, as well as the financial crisis.

This growth is driven by firms' internationalisation, since exports have experienced a similar positive trend in the period.

Industrial policy defined in 2015

The definition of enabling conditions for the adaptation and evolution of the regional industrial and wider socio-economic system has started with the collection of information and the analysis of the region's strengths and weaknesses, on the basis of meetings and conferences with regional stakeholders, particularly businesses. The region's most important sectors in terms of specialization were thus identified, as mentioned in the previous section (mechanical engineering, food, building, health industry and cultural - creative industries); they are broadly defined so that all existing industries could be included in this categorization. Regional competences in these sectors were mapped with a view to pointing out potential synergies and complementarities within and across sectors, as well as areas in need of support. As a result, 27 GVCs in the five main sectors have been identified, and seven associations, called clusters, and communities (Clust.ER) have been created to allow all the regional actors of the GVCs belonging to them to meet and interact, as well as defining common goals (Table 1).

Insert Table 1 about here

The regional tradition of social participation and involvement was stressed and renewed in order to define the new industrial development policy. Regional stakeholders, particularly businesses were consulted in order to identify their needs in terms of technological transfer, new infrastructural requirements, as well as skills. The outcome was the adoption of the Labour Pact in July 2015, considered as industrial development policy because it contains not only direct employment policy but also and primarily a set of actions aimed at supporting the industrial and economic development of the region, so as to provide jobs, hence decent living conditions.

Participative governance

The ER industrial policy is therefore characterised by a **participative governance** process, namely dialogue with stakeholders to define the policy and involvement in the policy implementation process, which is one of the enabling condition outlined in Section 2. This is achieved thanks to institutions such as the above-mentioned 'Conferenza per l'economia e il lavoro', and conferences and meetings with business, local authorities and representative and the civil society (in so-called 'tavoli di concertazione', consulting round tables). In addition, the government stresses the transparency of its procedures and commitment to avoid any corruption or infiltrations by criminal organisation, especially in the allocation of funds. The regional administration was also re-organised in order to favour this participative governance process and also policy coherence (Bianchi and Labory, 2014, 2018a). The connections and interactions between the stakeholders belonging to the regional system, and particularly those connected to industries, are favoured by the actions of a specific regional agency, ASTER. The latter was created in 1993 in order to promote the development of the regional innovation system, focusing on university - industry linkages. Its action has been extended not only to knowledge transfer within the region, but also outside, since for instance it deals with the participation of the ER region in interreg programmes and also in the Vanguard Initiative (see below).

Policy coherence

The fact that industrial policy is defined in a 'Labour Pact' reflects attention to **policy coherence**, namely coherence between policy fields. This is another enabling condition for the adaptation of the regional system. Job creation requires not only direct measures on industry (access to finance, to basic infrastructure, technological transfer, and so on), so that firms are created and grow, but also appropriate skills, which are formed in the education and training system, and regard social policies. In fact, social, innovation, human capital and territorial policies have been jointly and coherently defined in the region (Bianchi and Labory, 2011).

Regarding the coherence between levels of government, the regional industrial policy of the ER region mainly uses the funds of the European regional policy. Its objectives are therefore aligned with the European ones, particularly now the Smart Specialisation Strategy formulated in the Europe 2020 Strategy. In Italy, the competence of regions in the definition of industrial policy has been increased in the late-1990s. The law 112 of 31/03/1998 effectively delegated the definition and implementation of industrial policy to regions. The constitutional law of 2001 (n. 3), completed the reform of Title V of the Constitution by extending the competencies of the region in terms of legislation, particularly in the field of development policies, including industrial policy. The ER region started to formalised industrial policy in three-year plans in 1999. The plan is updated every year and allows the resources for development to be pooled in a common fund, thereby avoiding the scattering of actions in the different regional sectors and ensuring coherence.

The Labour Pact also includes actions for the unemployed and poorest people (social policy). Guidance for personalised career pathways, classroom and workplace learning, and assistance in starting a job are some of the actions designed for more vulnerable people, including the disabled. Traineeships and apprenticeships programmes have been strengthened for young people leaving school, for unemployed persons in search of jobs, and for people with disabilities, asylum-seekers, people entitled to international or humanitarian protection, and people requiring social protection. In this manner, the regional industrial policy favours the development of entitlements, or rights of access, of participation into the development process, and all parts of the regional system are considered in the policy, in order to avoid fragmentation that is likely to have a negative impact on the adaptation of the regional system.

In addition, measures for the development of capabilities and networking have often been jointly defined and implemented. These enabling conditions are particularly important and are broad, in the sense of comprising numerous aspects and therefore policy actions, so we explain them in more details relative to the first two enabling conditions.

Capabilities

Regarding **capabilities**, R&D and skills are viewed as particularly important in the current context. Regarding the former, measures have been taken to increase both public and private R&D in the region (R&D programmes for SMEs, attraction of external firms conditioned on their investing in R&D centres in the region, support to public R&D, etc.). Regarding the latter, the educational system was reformed starting in 2010, with a stress on technical and professional training, as well as research and its translation into industrial applications (Bianchi and Labory, 2018a). The region has four universities, in Bologna, Ferrara, Modena and Parma, as well as some divisions of the Milan Polytechnic and of the Catholic University of Milan. Overall these tertiary education institutions, together with important national research institutes located in the region, and ten technopoles created in the last years (in the various areas of specialisation of public and industrial research related to the main sectors of the region), contribute to a high

R&D capacity. Measures aimed at attracting investments in the region, in order to increase regional capabilities. These investments are conditioned on the fact that the firms set up R&D centres in the region.

Another important instrument is the integrated three-year plan, “Advanced skills for research, technology transfer and entrepreneurship” adopted in 2016, combining the regional educational and training infrastructure with the regional policies for innovation and industrial research. European Structural and Investment Funds (ESF, ERDF and EAFRD) share the same priorities, objectives, procedures and implementation schedules, in order to promote a dynamic regional innovation ecosystem, where the research world and the production world strongly interact and attract investment, entrepreneurial initiatives and creative talents. Instruments include grants and other financial aids for students in higher education, as well as for research projects in line with the Horizon 2020 strategic objective to support the conversion of new scientific knowledge into products and innovative services to meet social challenges; research grants and Ph.D. scholarships consistent with the entrepreneurial traditions of the region and the paths indicated by Smart Specialisation Strategy; actions to accompany processes creating new enterprises, and the growth and internationalisation of newly created businesses.

Besides this, the ER industrial policy comprises measures in favour of the integration between science, education and production (networking for complementarity). For example, a new education institution called Motor-valley university of Emilia-Romagna MUNER has been created in 2016, in order to provide appropriate skills for the integration of science and production in the motor and mechanical engineering sector. The regional government consulted the main producers located in the region, namely Ferrari, Maserati (of the FCA group), Lamborghini, Ducati (now in the VW-Audi group), which outlined the lack of human resources for their adaptation to the fourth industrial revolution. As a result, two Masters’ programmes involving the various companies (although competitors) and the regional universities have been created, in advanced automotive engineering and advanced automotive electronic engineering. The aim is to attract the best young talents both in the region and outside, in Italy and abroad.

The provision of appropriate infrastructure, namely communication, transport and energy, is another aspect of the development of capabilities. The region has been active in this respect. In particular, following Industry 4.0 and the prevailing claim that data are the main raw materials of the new era (see for instance Schwab, 2016), another important infrastructure has been recently added. Regional policy-makers consulted universities, firm managers and other stakeholders and realised that competencies and potential facilities regarding big data were substantial in the region. They put together a project to propose Bologna, the regional capital, as a host of the Data Centre of the European Centre for Medium-term Weather Forecasts (ECMWF). The project was presented as strategic, potentially providing not only the region but also the country with a key facility and capacity of big data collection and processing. The Italian government agreed and backed the proposal and provided funding for some of the necessary facilities. On 22 June 2017, the ECMWF Board formally accepted to establish its Data Centre in the Bologna location. A Big Data technopole has been created around the centre, comprising the research facilities of the CINECA (national supercomputing consortium) and the CNAF (National computing centre of the Italian nuclear physics research centre), together with the National Excellence Centre for Research and Innovation on Industry 4.0, sponsored by the National Ministry of Industrial Development. The Big Data Technopole also includes private

research centres, so that it is becoming one of the largest big data infrastructures in Europe, competing for excellence at world level.

Networking

The above measures aimed at increasing capabilities comprise networking elements: for instance, the new Masters programme developed with the automobile industry aims at providing appropriate capabilities to the regional industry, but it also favours networking within the region, particularly between industry and universities, allowing training of new engineers but also knowledge exchange on the latest technologies, and joint R&D projects. Thus **networking** for complementarities is the fourth important enabling condition favouring industrial structural changes, which the ER regional government has included in its industrial policy. This has two main dimensions: first, interactions between education and research institutions and industrial actors are strongly encouraged; second, the regional government also promotes linkages with extra-regional actors and institutions.

Regarding the first dimension, universities and research centres are related in networks also comprising the main industrial sectors of the region, particularly in the technopoles. In addition, an overlapping network of technical institutes has been created, the network of Polytechnics, providing the operational, analytical and relational skills that are crucial for innovation and for the processes of developing, raising standards and digitalising the industries of strategic importance for the growth of the region and the country. This network is made of technical colleges that offer highly specialised, two-year, post-school diploma programmes to train expert technicians that are useful for all regional firms but particularly SMEs, which do not have the resources to realise this type of training.

The Polytechnic Network overlaps with the innovation and research network in that both are complementary, providing the necessary knowledge and competencies for innovation to be translated into industrial applications, thereby contributing to the structural changes that industries have to go through in order to adapt to the fourth industrial revolution. The high-tech network corresponding to the main regional sectors exploits complementarities between the activities of regional stakeholders in order to favour innovation and industrial applications of research, and it is supported by corresponding networks of educational institutions, namely technical institutes, universities and apprenticeship and vocational training programmes. The meeting points of these networks are numerous, in the five strategic sectors of the region and the Clust.ER communities for instance.

Besides actions aimed at creating and exploiting complementarities between regional actors, the ER industrial policy is also open to the rest of the world, favouring the creation and exploitation external links. This is the second major dimension of the promotion of networking. Thus, the region has undertaken prospection of potential links, both in the EU and outside; it has seven partner regions, with which it develops close relationships in all fields: these are Hessen (Wiesbaden – Frankfurt in Germany), Aquitaine (France) and Wilkopolska (Poland) in the EU, and California (USA), Gauteng (South Africa) and Guangdong (China) outside Europe. In addition, the ER region is member of various Interreg programmes, such as Adrion with regions bordering the Adriatic and Ionian seas, the Italy-Croatia programme, the Alps programme, etc. It is also member of the EUSAIR macro-region comprising Balkan countries. These programmes regard the common economic, social and environmental interests of the member regions and countries, such as sustainable development of the sea, preservation of cultural heritage, and

sustainable tourism and fishing. As an example, projects promoting innovation for sustainability and upgrading of SMEs are financed in these programmes.

The ER region is also member of the Vanguard Initiative, an association gathering the most advanced regions in the Europe, created in 2013 with the Milan Declaration. The aim of Vanguard is to favour the identification and exploitation of complementarities between economic actors – mainly enterprises – of the member regions. Its approach is bottom-up, starting from business initiative, with a view to creating links and favour learning and knowledge creation along the value chain, with the concrete aim of promoting commercial applications of research. The association has been active in financing the realisation of democases, namely prototypes concretely transforming innovation in commercial applications, which represent high sunk costs for industries. Businesses are invited to propose pilot actions in five main fields, namely advanced manufacturing for energy applications (ADMA Energy), 3D Printing, Bio-Economy, Nano-technology and Efficient and sustainable manufacturing. The budget of the association is made of the contributions of the member regions, and the association is active in looking for additional European funds to support its projects.

Conclusions

This paper has argued that regional industrial policy has a key role to spur socio-economic development, hence growth and jobs. Industrial policy aims at promoting structural changes, which are rooted in changes in production processes, due either to new technologies or new products. Today both globalisation and the fourth industrial revolution are inducing substantial structural changes in industries, which strongly call for industrial policy at territorial level.

These structural changes concern the long-term transformation of regions. The evolutionary economic geography focuses on this time perspective, emphasising the multiplicity of possible evolutionary trajectories depending on history and social, economic as well as political conditions. From a theoretical point of view, this paper considers of regions as complex adaptive systems as in the evolutionary geography approach and uses insights from the theory of complex system to outline the main elements of regional industrial policy. In this perspective, the individual and collective decisions that interacting individuals and organisations make may determine a particular development path for their regional system. By defining and implementing industrial policy policy-makers consciously push for some solution, favouring specific development paths by providing enabling conditions for the system to embark on it.

The main elements of regional industrial policy are the main enabling conditions. In this competitive but highly interdependent global context territories have to become hubs of knowledge and competencies that favour the reshaping or emergence of global value chains. A first important enabling condition is therefore the development of capabilities, particularly R&D and skills to be able to upgrade existing products and processes and develop new ones, but also infrastructure (communication, energy, transport). Strategic choices have to be made in order to promote particular development paths, which the regional ecosystem embark on if appropriate complementarities are created, both within and outside the region. The second important enabling condition is thus networking for complementarity building and exploiting. Within the region, high institutional density is required (Amin and Thrift, 1994), with overlapping and complementary networks of business, education and research, and other institutions. Outside the region, creating complementary links with institutions and businesses

in other regions in the same country and abroad, so that regional networks relate and combine with wider networks, is essential. This intense networking based on institutional density works if the region has the appropriate resources and provisions. This implies that regional industrial policy has to be implemented in coherence both with other policy levels, national and supranational, and with other policy fields, namely social, educational, environmental, and so on. Policy coherence is thus a third enabling condition.

The fourth enabling condition set up by regional industrial policy to favour long-term adaptation and evolution is participative governance. As stressed in this paper, the involvement of regional stakeholders in the policy process is key in order to both access relevant information and knowledge for decision-making, and also mobilise all parts of the regional system towards the agreed and shared objectives.

In this manner regional industrial policy can succeed in creating and capturing value (Bailey et al., 2018). These arguments have been illustrated in a particular case, that of the Emilia Romagna region in Italy. While this region has implemented industrial policies since the 1980s, supporting new industries and SMEs, a new strategy has been defined over the last ten years aimed at consistently building complementarities for the regional industries. This industrial policy is not a policy of the past, where a subsidy or one action was undertaken to reach an optimum, as if economic evolution could be perfectly deterministic. The new industrial policy aims at favouring complex structural changes by providing enabling conditions for the socioeconomic system to adapt in a coherent and flexible manner and embark on favourable development paths. It is a pro-active policy, trying to anticipate changes and prepare the regional system for its evolution and adaptation, so that the regional government acts as catalyst for changes.

Although this paper illustrates what can be a complexity approach to industrial policy at regional level, it considers only one case, not providing systematic evidence. In addition, the paper has focused on 'positive' enabling conditions, namely conditions that favour changes, and not on the control of inhibitors that may impede changes, such as conflicts of interests making dialogue among stakeholders difficult, institutional failures, or other barriers to adaptation, particularly those related to market structure. The consideration of less successful cases, such as lagging regions, should provide insights on these aspects. This is what we intend to address in future research.

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Table 1. Sectors of specialisation defined in the Emilia Romagna region

7 Clusters comprising 27 global value chains	5 priority sectors (smart specialisation strategy)	Corresponding and overlapping networks
Agrifood	Agrifood	Universities and research centres
Health (health and wellbeing)	Health	
Mech (Mechatronics and automotive)	Mech	Polytechnics
Build (building and construction)	Build	
Create (culture and creativity)	Innovation and creativity	Technopoles
Innovate (innovation in services)		
		Startups
		...

Source: authors' elaboration on the basis of regional documents and interviews with stakeholders.