Mapping the regional strengths in a key enabling technology: the distribution of Internet of Things competences across European regions

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Objectives

Enabling technologies are knowledge-intensive technologies associated with intensive R&D, rapid innovation cycles, significant investment costs and highly qualified labour (European Commission, 2009). Thanks to their novelty and pervasiveness, these technologies are capable of driving innovation in products, processes and services across all sectors of the economy. Enabling technologies play a crucial role in economic development (Adner and Levinthal, 2002). Harnessing the potential of key enabling technologies to drive economic growth and job creation can be an important development strategy for regions, particularly in high-income economies (Laursen, 2000). To harness such potential, however, regional economies need to possess the required competences. Because these technologies are usually complex and require the integration of many different competences, provided by different firms (Teece, 2018), the presence of a sizeable set of firms providing core elements of the technology, or parts of the value chain, is crucial for a region to be 'on the map' of industrial development. Having the required technological competences can allow the region to lead in technology development, to identify new applications of the technology leading to new potential markets, and to diversify into related technologies (Cooke and Schwartz, 2008). In fact, current competences strongly influence the possibility of further technological advancement along the same technological trajectory (Boschma et al., 2013; Heimeriks and Boschma, 2013; Kogler et al., 2013), as well as the potential for discovering new applications of the technology, which pave the way for market expansion. They also provide the building blocks for further diversification into related technologies (Boschma and Frenken, 2011; Neffke et al., 2011).

In this study, we focus on the Internet of Things (IoT), which, according to many scholars and experts, qualifies as a key enabling technology (McKinsey Global Institute, 2013; Rong et al., 2015), and we propose an original methodology to map the regional distribution of competences in this technology in Europe, in order to better understand the extent to which European regions are able to harness their potential to drive further growth of the industry.

IoT is one of the four essential enabling technologies that support the new approach to the organisation of work and production known as Industry 4.0, the others being cloud services, big data, and analytics (Frank et al., 2019). The core principles of Industry 4.0 are (i) integration (GTAI, 2014) – between the physical system and the software system, between industry and services (Hermann et al., 2016), and (ii) connectivity (Metallo et al., 2018). IoT is crucial for Industry 4.0 because it includes a set of technologies that enable the collection and transmission of data between devices; as a result, interconnected and integrated objects can be identified, located, tracked, monitored, and made to communicate with each other (de Sousa Jabbour et al., 2018; Li et al., 2017). IoT solutions increase the efficiency and flexibility of existing processes, and enable the development of entirely new processes, products and services (Oriwoh et al., 2013; Kang et al., 2016; Frank et al., 2019). Firms become better able to flexibly adapt to market changes (Wei et al., 2017), realising higher value for both customers and themselves (Frank et al., 2019). IoT applications are found in numerous fields, including smart industry, healthcare, mobility solutions and logistics (Rossi et al., 2020).

Since the development of any IoT solution requires the integration of different technologies, both hardware and software, and of additional services, and because the relevant competences are often distributed across different firms, we can expect different regions to host specific combinations of IoT competences, and thus exhibit different ability to harness the potential of this key enabling technology. With the aim to analyse how these key competences are distributed across European regions, and to evaluate the regions' potential for advancement with respect to IoT, in this study we address the following research questions: (i) What are the prevailing IoT competences in different European regions? (ii) Based on their current competences, what regions exhibit the greatest potential for further expansion of their IoT technological and market capabilities?

Methodology

To address these questions, we map IoT-related competences at regional level, for 18 European countries, deploying an original methodology designed specifically to deal with the constraints that arise when mapping the geographical distribution of competences around new technologies. Our methodological approach relies on text mining of firms' own descriptions of their activities, in order to identify combinations of NACE codes pertinent to IoT, at a high level of disaggregation, which we then use to map competences at regional (NUTS3 and NUTS2) level. This approach allows us to overcome the problems inherent in directly using the standard descriptions of organisations embedded in NACE codes, since such codes pre-date the arrival of IoT and do not adequately represent the activities related to it, with some activities spanning different codes, or failing to be precisely captured by any of the existing codes.

In order to map the application potential of the IoT technologies across European regions, we develop a five-step methodology, using textual analysis applied to the description of companies’ activities.

We identify clusters of regions characterised by different mixes of competences in IoT technologies, and we discern leader, co-designer and supplier regions, based on the complexity of competence bundles they possess.

Results & policy implications

Building on a classification of the architecture of IoT solutions and the obtained regional mapping of IoT domains of those solutions, we are now able to single out the potential development of IoT of the European regions in the 18 countries under analysis. Three main groups of IoT regional systems - Leaders, Co-designers, Suppliers - can be distinguished in terms of their potential for technological and market capabilities expansion (high, intermediate, low).

We find some evidence that regional competences in IoT build on the regions’ existing knowledge bases: for example, specialisation in hardware is prevalent in regions with high manufacturing employment, while specialisation in software is prevalent in regions with high employment in advanced services. The full IoT value chain tends to be present only in densely populated, urban, often capital city regions. This further confirms the findings from the economic geography literature, which suggest that new technologies build on the competences already available in the region.

We also find that some countries have more homogeneous profiles than others, with particularly heterogeneous profiles in central European countries and more homogeneous profiles at the periphery.

We contribute to the literature by providing the first mapping of IoT competences across Europe, which can prove useful for several constituents. First, our findings could assist public policy to better understand the needs of the regions with regard to IoT as well as the strengths they can leverage. Second, by indicating where IoT competences are located, our study can assist companies in their investment decisions. Third, our findings can inform researchers and students interested in IoT about the locations in which it is possible to find specific competences relative to IoT, which can assist them in their professional choices.

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