Ubiquitous technologies and 5G development. Who is leading the race?

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THE EVOLUTION OF "GENERATIONS" OF TECHNOLOGIES IN MOBILE COMMUNICATION

- The **mobile telecommunications industry** is used to frequent technological "generations" updates, almost every decade (Cave, 2018; Oughton et al., 2018; Han and Sohn, 2016).

- However, the fifth generation of mobile promises a **much deeper change** than ever previously occurred (Teece, 2018) **going well beyond the telecommunication industry** (Cave, 2018). The 5G is actually expected to drive at least three new areas of industrial change:
  - IoT that will facilitate the adoption for smart homes and smart cities domain (Aazam et al., 2018).
  - Vehicle automation, healthcare, smart farms (Anwar and Prasad, 2018).
  - Augmented reality and virtual reality (Hsieh, 2018; Chang, 2019).

- In this respect **5G may be a next candidate to become a General-Purpose-Technology** (GPT) maybe not on the same standing as electricity or the Internet. In fact, GPTs are characterized by:
  - pervasiveness across most sectors of the economy;
  - fast evolution and self regeneration;
  - ability to enable further products' or process' innovation.

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- The debate regarding the 5G development, implementation and disruptiveness is gathering growing attention (Cave, 2018, Campbell et al., 2017; Rao et al., 2018), a key concern emerges: the **growing complexity** of the 5G technology may act as a **barrier to the new entrants**?

- Apparently, only a **handful of companies** lead the **development of the 5G standards** (Huawei, Qualcomm, Intel, Samsung, LG, Nokia, Sharp and NTT DOCOMO). The crucial question is: will this become a factor hampering global competition?

- This paper addresses the **technological and business environment's complexity of the 5G ecosystem** and the related **implication for competition and innovation**, following the growing literature on economic and technological complexity (Hidalgo and Hausmann, 2009; Balland and Rigby, 2017).

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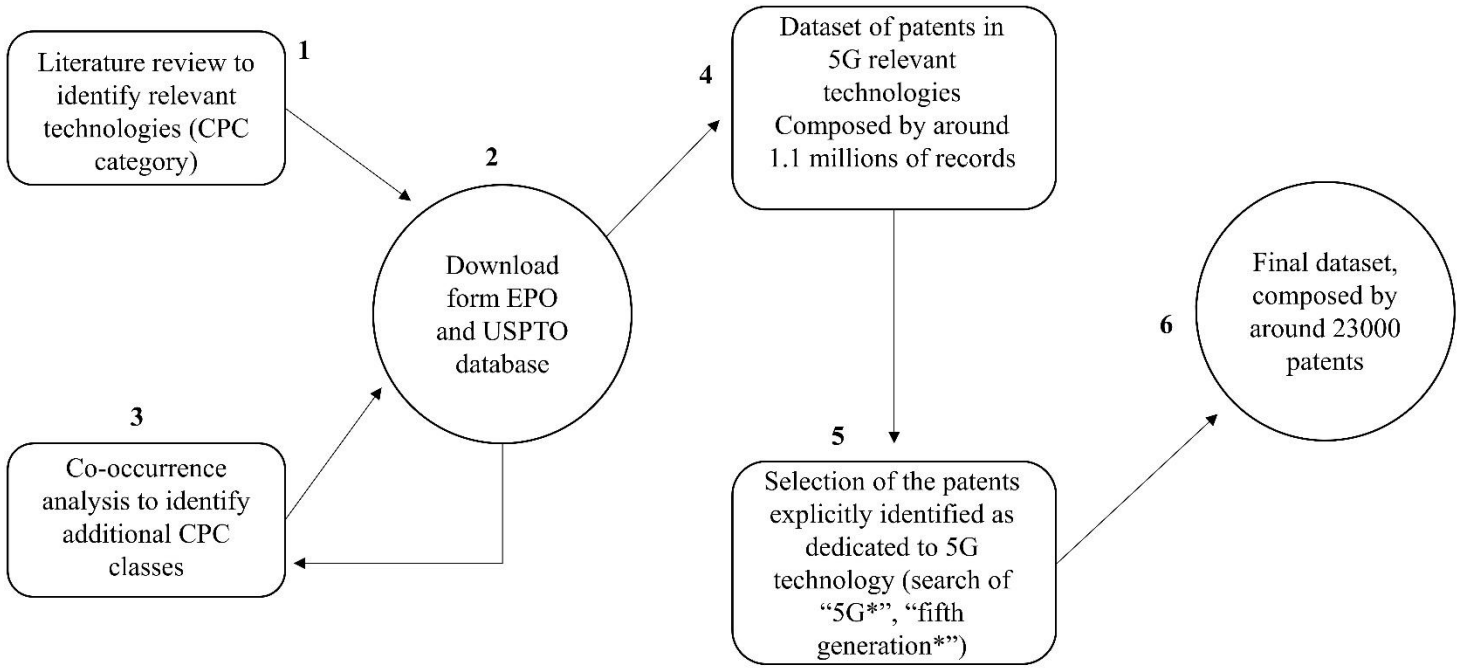
THE INCREASING COMPLEXITY OF 5G TECHNOLOGIES

- The concept of **complexity** following Hidalgo's seminal work (2009) is based on two main characteristics:
  - **Diversity:** how many different technological specialisations are present in a country;
  - **Ubiquity:** how rare are these technological specialisations.

- The idea is that if **many different technological specialisations** are needed to advance in a particular technology and if these **specialisations are also rare**, the complexity of the technology will be high.

- There is a lack of studies connecting complexity to access to technologies and market competition. **More complexity** will lead to a net of global "oligopolies", with **few actors around the globe developing and holding crucial technologies such as the 5G** and this is a matter of research and policy concern.

RESEARCH DESIGN



Source: elaboration of the authors.

- Cooperative Patent Classification (CPC) represent the technological classes to which the patent pertain. The **main CPC** involved in the 5G results to be the following four:
  - **H04** "electric communication technique";
  - **G06** "computing; calculating or counting";
  - **H01** "basic electric elements";
  - **H03** "basic electronic circuitry"

- The **number of patents addition** in these technological classes **increased** yearly from few more than 50.000 in 2010 to more than 140.000 in 2019.
- The **average number of CPC involved** in each of these patents **increased** form few more than 1.2 in the 2010 to almost 2.5 in 2019.

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METHODS

- As many others we are using **patents as a proxy for innovation** and future competitive capability in 5G.

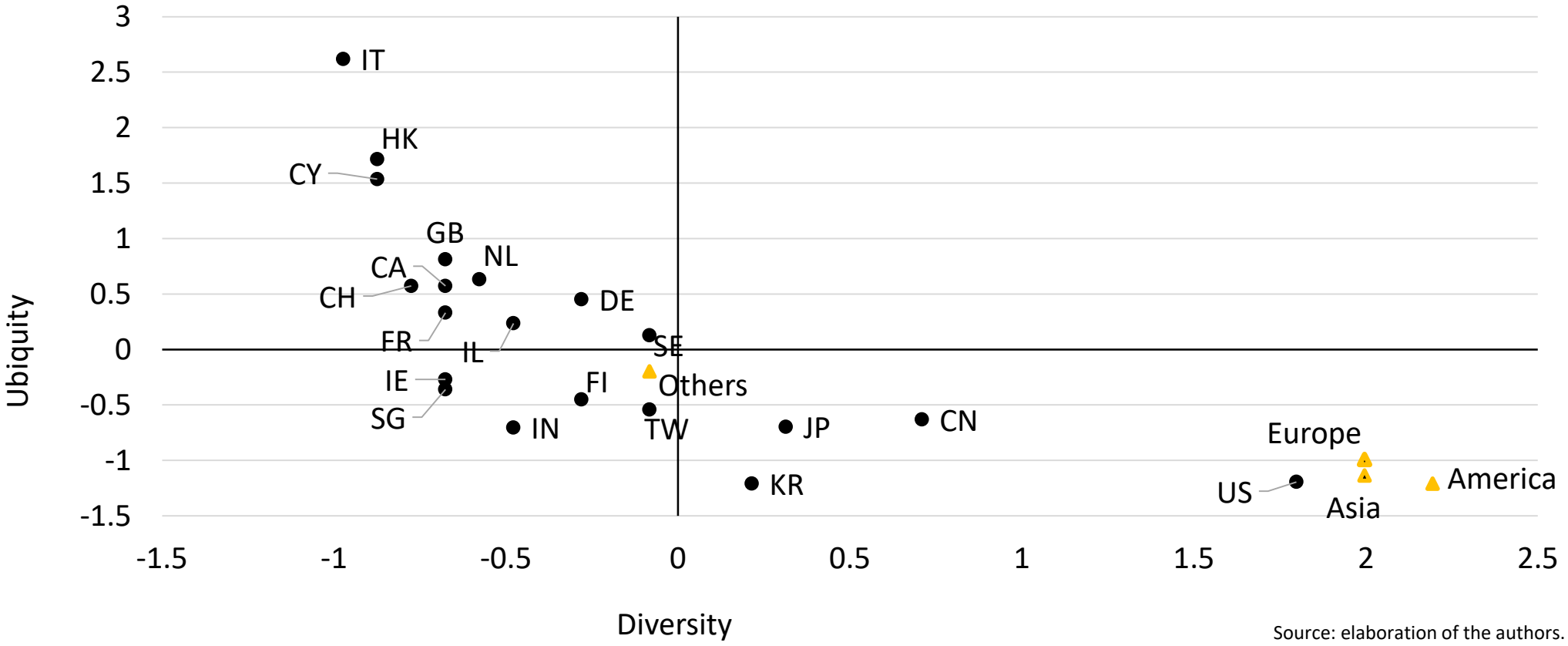
- But to understand the leadership regarding 5G technology it is necessary go **beyond the simple counting of patents,** that is what our research tries to do.

- **We have taken inspiration from the literature on complexity** in the attempt to find a more advanced tool to assess the innovation race.

- We firstly concentrate on the two key features of existing patents related to 5G: **diversity** i.e. how many different technologies a country is able to license in the technology and **ubiquity** i.e. how rare are the technologies licensed.

- These two dimensions taken together give a first indication of **where the technological race for 5G stands at the end of 2019**.

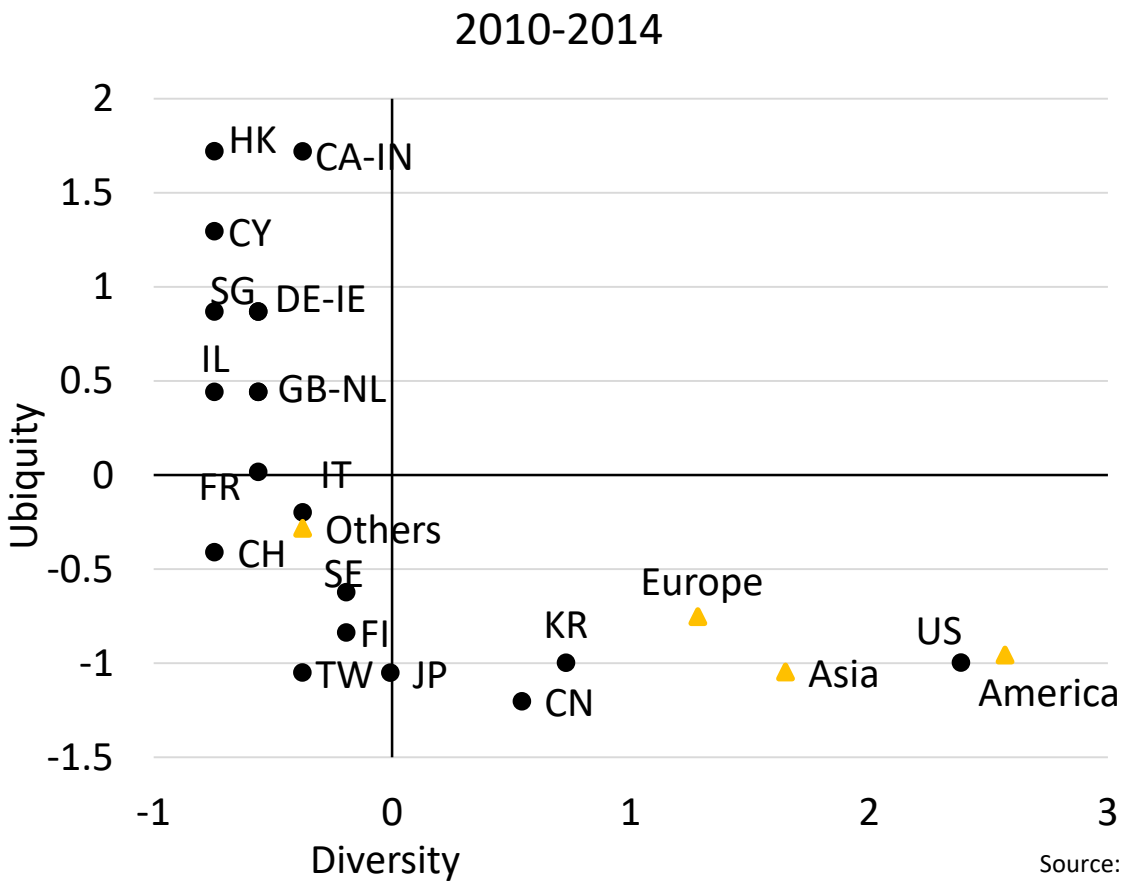
DIVERSITY AND UBIQUITY 2010-2019 TECHNOLOGICAL SPECIALISATIONS FOR THE MOST "INNOVATIVE COUNTRIES"

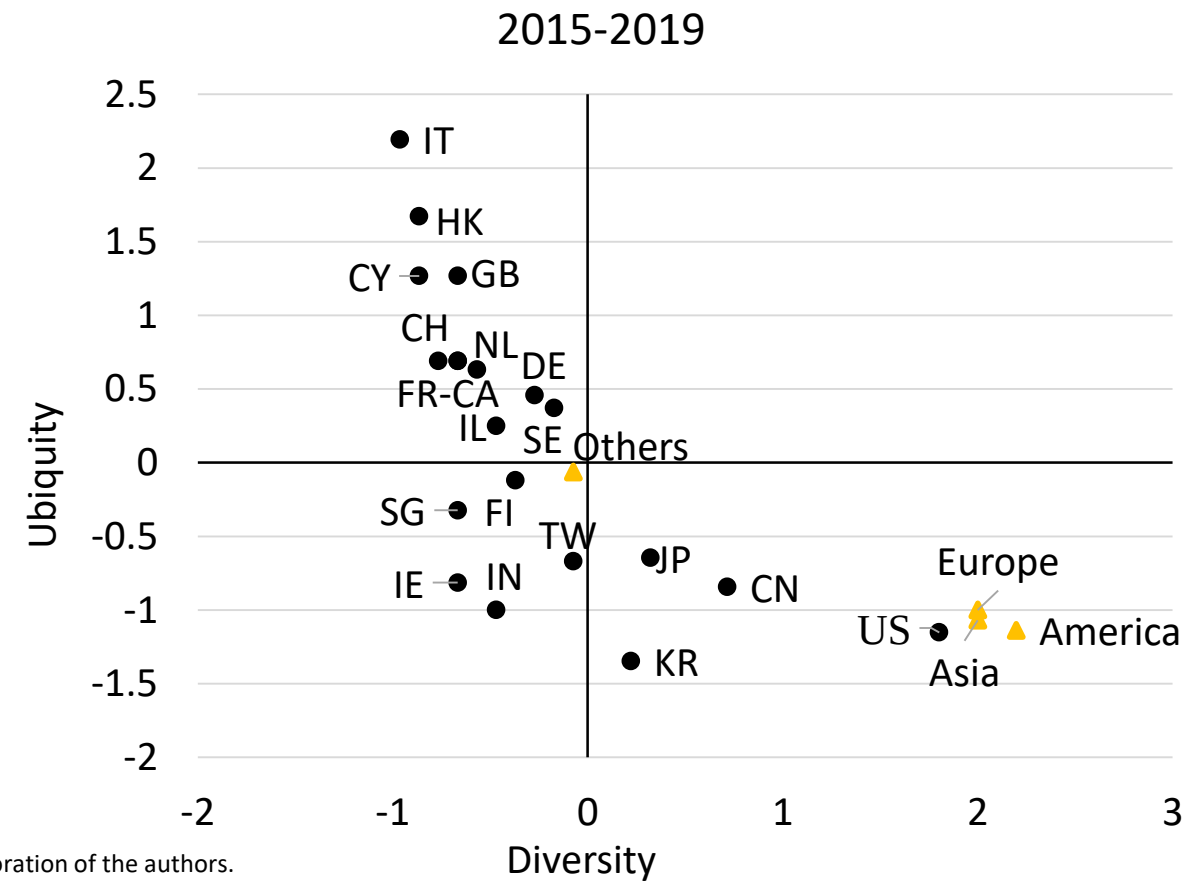


Source: elaboration of the authors.

All the countries in the lower-right quadrant (US, China, Korea and Japan) can be considered as the leaders in the 5G technology, apparently owning many (diversity) and rare (ubiquity) specialisations.

DIVERSITY AND UBIQUITY TECHNOLOGICAL SPECIALISATIONS 2010-2014 AND 2015-2019 "MOST INNOVATIVE" COUNTRIES.





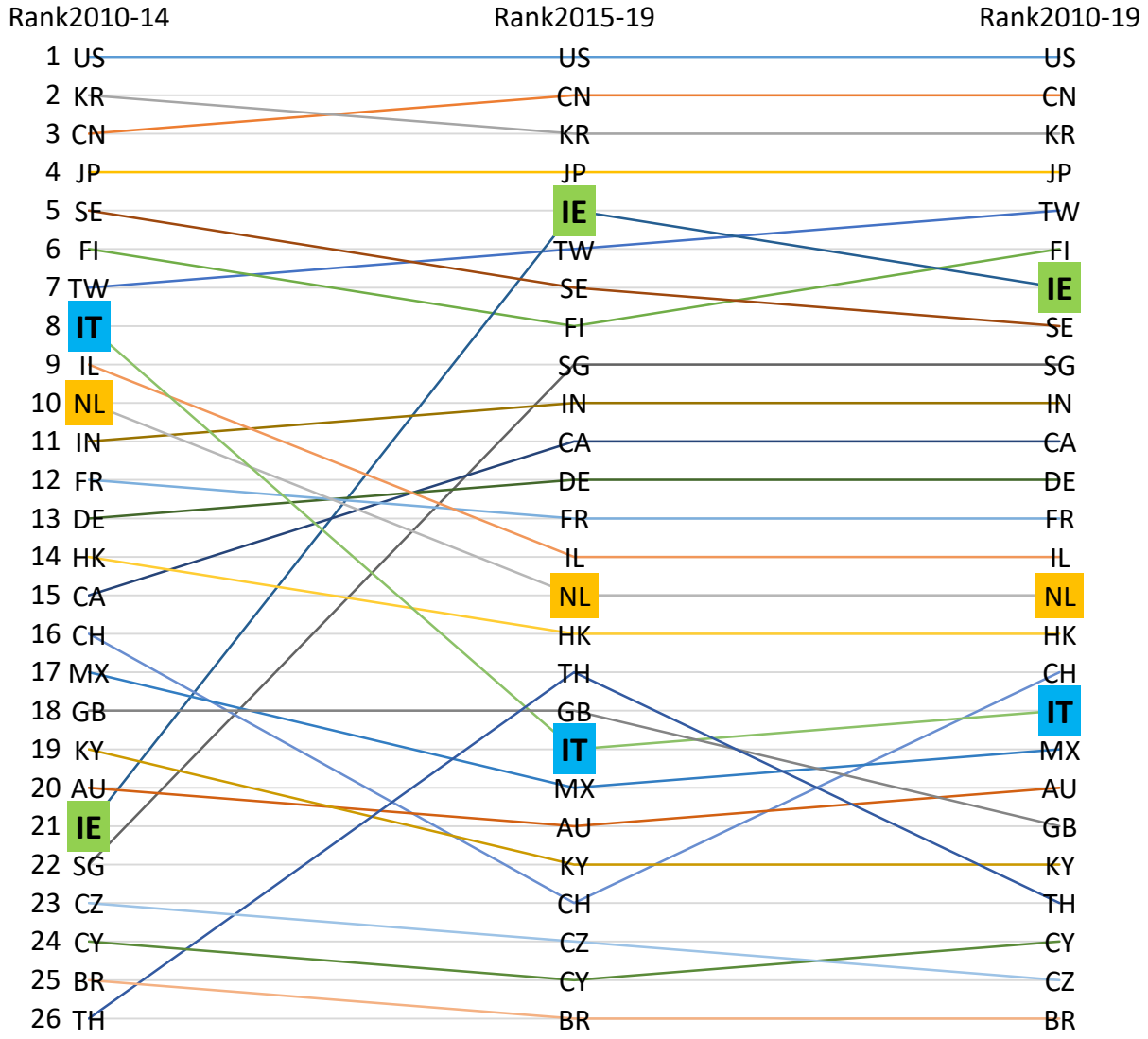
Source: elaboration of the authors.

TECHNOLOGICAL COMPLEXITY INDEX RANKING EVOLUTION 2010-2014; 2015-2019; 2010-2019

We measured the complexity following the second eigenvector method (Tacchella et al., 2012; Balland and Rigby, 2017).

The results of diversity/ubiquity pattern and of the complexity show that:

- **US and China** are clearly **leading** the development of 5G.
- **A fragmented Europe seems practically out of the race,** but there are indications that if the EU could be capable to coordinate the innovation effort of its member states, maybe it may still emerge as a valid competitor.



Source: elaboration of the authors.

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CONCLUSIONS

- The paper suggests a route forward to **understand the technological competition in the telecommunications industry**, particularly for the development of the 5G technology.

- It shows that there are only a **few countries at the frontier of the technological development of the 5G** and it seems likely that **lagging countries** will face many difficulties in catching up with the leaders, even worse, the time dynamic of complexity apparently is accelerating and the **gap appears to be increasing over time**.

- Regarding **Europe**, the actual fragmentation show that the **gap to be covered is important** but the situation could significantly **improve if the countries within the EU were able to develop the right incentives to cooperate more closely**.

- Clearly, **the time for a European unification and acceleration of the effort to compete in 5G and beyond seems limited**…

- In any case, **global cooperation** in the technological fields is **crucial to unlocking the expected 5G benefits beyond the leading countries**.

LOOKING AHEAD: THE DEPLOYMENT OF 5G

Despite the crucial importance of the debate on 5G technological leadership the **other relevant discussion regards the deployment of 5G**.

Also in the **deployment at present Europe is lagging behind**, given the challenges related to investment in what appears, if compared to other regions of the world (e.g. South Korea, China, USA), to be a quite fragmented industrial landscape (Lemestra, 2018; Blackman and Forge, 2019).

There is the need and the possibility for a strategic rethinking of the policies that promote 5G's deployment in Europe, which appears crucial in determining the future influence of 5G on the digital economy?

Could be appropriate to develop an industrial policy that takes on the whole Union as the scale of action, instead of just the single Member States, integrating technological leadership and industrial deployment as the relevant parameters of international competitiveness? The answer to this question clearly is the topic for another paper.