Innovation in 5G technology: leadership, competition and policy issues

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My contribution today

- To provide an overview of the *Telecommunications Policy* Special Issue, with the aim to highlight some common themes emerging from a joint reading of the papers
- To present a capsule summary of my own paper in the Special Issue
The approach taken in the SI: 5G as a GPT

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<th>GPTs are technologies...</th>
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<td>(1) pervasive in their use;</td>
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<td>(2) intrinsically capable of self-regeneration and ongoing technical improvement;</td>
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<td>(3) enabling further downstream innovation in application sectors</td>
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(2) + (3) = “innovational complementarities”

- This motivates interest in 5G, as adoption of GPTs is key to productivity improvements – a theme relevant for most countries, and particularly for those experiencing productivity slowdowns.
- It provides a lens through which organizing thinking around 5G innovation:
  - generation of knowledge and technologies that are progressively incorporated in the 5G standard – can be analysed quantitatively, as a wealth of data is now available
  - downstream innovation – can be analysed with a comparatively more speculative approach, and a focus on policy levers that may influence overall value creation
Innovation in the 5G standard: overview of contributions

3 contributions aim to identify leadership patterns and to explore the geography and dynamics of 5G-related knowledge creation.

Value added from these contributions:
(1) They go beyond mere count of patents and standard contributions as measures of companies’ and countries’ relative position in the “5G race”
(2) They broaden the set of measures to encompass publications, which provide a different view of participation to 5G development.

Parcu, Innocenti, and Carrozza, “Ubiquitous technologies and 5G development. Who is leading the race?”
- Focus on EPO and USPTO patents (2010-2019)
- Provides relative positioning of countries w.r.t. 5G innovation as captured by two measures of technological complexity (diversity and ubiquity), useful to capture competitive advantage in 5G innovation.

Buggenhagen and Blind “Development of 5G – Identifying organizations active in publishing, patenting, and standardization”
- Considers patents, standard contributions (technical/non-technical) and publications (2010-2021)
- Offers overview of companies/countries’ position and highlights correlation between the 3 measures for SEPs licensors.

Mendonça, Damásio, Charlita de Freitas, Oliveira, Cichy, and Nicita “The rise of 5G technologies and systems: a quantitative analysis of knowledge production”
- Bibliometric analysis of scientific publications through time (2005-2020), with info on their quality (e.g., citations, content)
- Finds prominence of China in terms of total citations, of the US in terms of citations/publication. Both are only in middle position in terms of Scimago journal ranking metrics.
Innovation in the 5G standard: what do we learn from a joint reading of the contributions?

- **Increasing complexity** of 5G technologies through time
- **Increasing concentration** of patents and standards in few countries/companies, decreasing concentration of research

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<th>Share of 5G peer-reviewed articles</th>
<th>Share of all citations to authors in a geographical area</th>
<th>Share of 5G patent families</th>
<th>Share of 5G accepted weighted standard contributions</th>
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<tbody>
<tr>
<td>China</td>
<td>25%</td>
<td>19%</td>
<td>41%</td>
<td>38%</td>
</tr>
<tr>
<td>US</td>
<td>11%</td>
<td>16%</td>
<td>16%</td>
<td>18%</td>
</tr>
<tr>
<td>EU</td>
<td>25%</td>
<td>29%</td>
<td>11%</td>
<td>24%</td>
</tr>
<tr>
<td>South Korea</td>
<td>6%</td>
<td>7%</td>
<td>22%</td>
<td>9%</td>
</tr>
<tr>
<td>Japan</td>
<td>2%</td>
<td>1%</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>Others</td>
<td>31%</td>
<td>27%</td>
<td>2%</td>
<td>8%</td>
</tr>
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When considering EU countries together, under the hypothesis of coordinated action, EU position in the global “5G race” improves significantly

- The EU appears relatively more focused than the US and China on contributing to the less appropriable part of 5G innovation
Downstream innovation: overview of contributions

5 articles address policy issues that influence innovations complementary to the 5G standard

Value added from these contributions:

1) They address a **wide range of policy levers** relevant to 5G innovation

2) They **deepen our understanding of ongoing policy debates**

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**Kú’s and Massaro “Analysing the C-Band spectrum auctions for 5G in Europe: Achieving efficiency and fair decisions in radio spectrum management”**

- Analyses impact of a range of choices in the design of spectrum assignment on network availability
- Highlights heterogeneity of NRAs’ choices in terms of equity and efficiency

**Knieps and Bauer “Internet of things and the economics of 5G-based local industrial networks”**

- Explores how spectrum policy choices influence cost-benefit profiles of alternative solutions for implementing 5G industrial networks
- Argues in favour of a hybrid spectrum policy approach that fully preserves the possibility of trial-and-error processes

**Nikolic and Galli “Patent pools in 5G: The principles for facilitating pool licensing”**

- Highlights why benefits from patent pools are particularly sizeable with 5G licensing
- Proposes a set of five policy principles meant to facilitate pool licensing in the IoT
5 articles address policy issues that influence innovations complementary to the 5G standard

Value added from these contributions:
(1) They address a **wide range of policy levers** relevant to 5G innovation
(2) They **deepen our understanding of ongoing policy debates**

**Bauer and Bohlin “Regulation and innovation in 5G markets”**
- Addresses a wide set of regulatory instruments that may affect horizontal and vertical business relationships along the 5G-enabled value chains
- Proposes a new approach to regulation in 5G-related domains: innovation-centered and general equilibrium

**Rossi “The advent of 5G and the non-discrimination principle”**
- Explores how the non-discrimination principle, which informs aspects of both upstream and downstream regulation relevant to 5G, should adapt to technological evolution in order to maximize the value created through innovation
- Cautions against overly rigid interpretations of the principle in a context characterized by significant uncertainty
Innovation in applications: what do we learn from a joint reading of contributions?

Two common themes:

- **Uncertainty** in the evolution of 5G-related technologies should be taken seriously in any policy attempt at reaping the benefits from 5G innovation.
  - committing to rigid interpretations of rules, mostly backward-looking and derived from past practices, risks jeopardizing “innovational complementarities” in a context characterized by radical uncertainty.

- The prospective evolution of 5G innovation requires a **much greater extent of differentiation in the type of policy tools adopted and the acceptable contractual arrangements** among different players.
  - this is connected to the GPT nature of 5G and holds particularly for spectrum assignment and SEPs licensing.
My own paper in the SI: 5G and the non-discrimination principle

- Value added of the paper: to provide a unified view of non-discrimination across both upstream and downstream regulation domains relevant to 5G:
  - non-discrimination in FRAND licensing of SEPs
  - network-level non-discrimination
  - technological neutrality

- Focus on how the design of the principle balances incentives to invest in common inputs (networks and essential patents) and in their applications

- Main policy insights:
  - Some declinations of the ND principle are technology-dependent and market-structure-dependent and are made obsolete by technological evolution (Smallest Saleable Patent Practicing Unit (SSPPU) in SEP licensing; notion of “specialized services” in the context of network neutrality rules)
  - The opportunity cost of limiting contractual and organizational freedom through rigid interpretations of the ND principle is higher in presence of 5G-induced uncertainty; rules forcing uniformity should be reconsidered (zero-pricing in network neutrality, induced adoption of vertically-separated organizational forms and uniform SEP royalties)
Concluding remarks

- While one of the themes of the SI is the issue of assessing current leadership in 5G development, it should be kept in mind that 5G is a standard, whose purpose is to maximize adoption
  - The “race” dimension should not be over-emphasized, as the benefits from the 5G standard will in the end have a global reach

- Policy choices may have an important impact on the timing of 5G diffusion and on the extent of complementary 5G innovation that will unfold at the local level
  - These considerations should be incorporated across the many policy domains that affect 5G innovation
Thank you for your attention!

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