

Using Patent Landscapes for Technology Benchmarking: A Case of 5G Networks

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Abstract: Patent Landscape Reports (PLR) have long been used in business, science and R&D. They enable data-driven decision making and minimizing the risks of strategic technology choices. The authors analyzed the patent landscape for 5G wireless communications using the PatentSight® software product. Among the companies, the clear leader by the Patent Portfolio Index is Samsung Electronics; among countries, it is USA and China. However, patents of high technological relevance and/or commercial value may appear in small tech companies, or as a “by-product” of other corporate activities. The research results are of interest to researchers and practitioners involved in the development and implementation of 5G technologies.

Keywords: patent landscape, 5G, Patent Assets Index, technological relevance, market coverage, competitive impact

1. INTRODUCTION

The patent landscape is a systematic study of patent documents that identifies and visualizes trends in business, science and technology. Patent landscape reports usually focus on one industry, technology, or geographic region. *Patent Landscape Reports* (PLRs) support informed decision making and are designed to effectively address high-stakes challenges in various areas of technology, thereby increasing trust. Through patent analytics and PLR, these critical decisions can be made using evidence that provides informed choices and mitigates decision-making risks [13].

This patent study focuses on *5G technology*. 5G stands for fifth-generation cellular wireless communications, and the initial standards for it were established at the end of 2017. Since 2019, mobile operators have begun rolling out 5G networks around the world. The main advantage of the new networks is that they will have higher bandwidth, providing higher data transfer rates. Thanks to the increased network bandwidth, mobile operators will be able to compete with ISPs providing cable Internet services. Besides, latest generation wireless networks open up a whole range of new applications in the *Internet of Things (IoT)*, *Augmented/Virtual Reality*, *M2M systems* [9].

The study used patent analytics provided by LexisNexis (founded in 1977, is part of the largest transnational information holding RELX Group). *LexisNexis IP* is a global leader in information solutions and services to meet the needs of the intellectual property market, government agencies, and academia. The company aggregates data from 111 patent offices around the world [1].

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2. THEORETICAL BACKGROUND

5G publications began to appear in 2014, and since then their number has grown steadily. We used the *Web of Science*® database, which is one of the most widely used reference databases for scientific periodicals. For information retrieval, we used the '5G' query with the category constraint 'TELECOMMUNICATIONS.' The request returned 7093 publications. Fig. 2.1 shows the dynamics of the number of publications from 2014 to 2019.

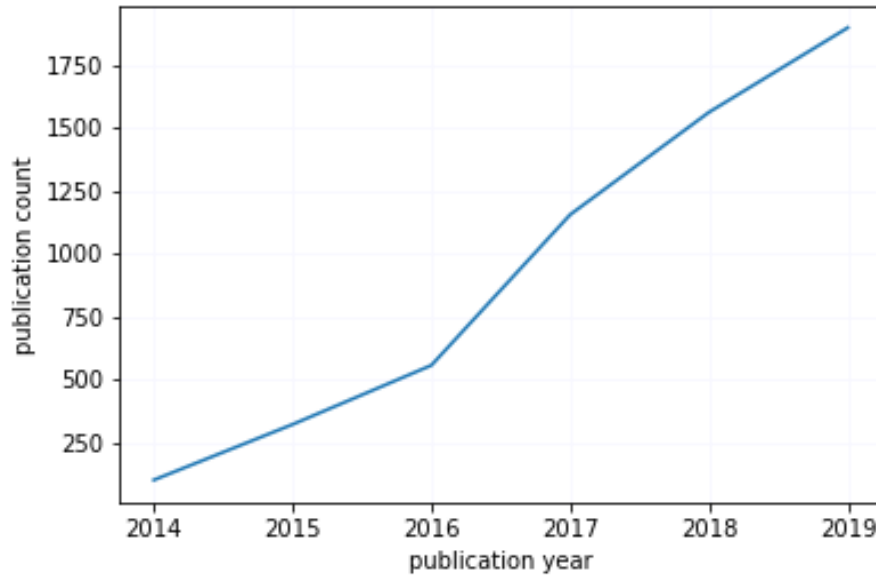


Fig. 2.1. Dynamics of 5G-related publications. Data source: Clarivate Analytics Web of Science®.

We visualized the 5G scientific landscape using *VOSviewer*® as in [7] (Fig. 2.2). It is a software that enables creation, visualization and analysis of network maps based on bibliographic data. *VOSviewer*® also offers text mining functionality that can be used to construct and visualize co-occurrence networks of important terms extracted from a body of scientific literature [18]. *VOSviewer*® pays special attention to the visualization of bibliometric maps. *VOSviewer*'s functionality is especially useful for displaying large bibliometric maps in a simple and efficient way. It is especially useful for maps containing at least a moderately large number of items (e.g., at least 100 items) [15, 16]. The software is based on the idea of association strength:

$$S_{ij} = \frac{C_{ij}}{C_i C_j} \tag{1}$$

where S_{ij} is the similarity measure, C_{ij} is the co-occurrence of i and j , and $C_i C_j$ the expected number of co-occurrences of i and j under the assumption that co-occurrences of i and j are statistically independent. S_{ij} takes values in the range [0, 1]. *VOSviewer*® applies the link strength [14] by default. Then, the program uses the mapping technique detailed by [17]. Finally, *VOSviewer*® assigns the network nodes to clusters; the clustering technique is presented in [19]. *VOS* determines the locations of items in a map by minimizing

$$V(X_1, \dots, X_n) = \sum_{i < j} S_{ij} \|X_i - X_j\|^2, \tag{2}$$

subject to:

$$\sum_{i < j} \|X_i - X_j\| = 1. \tag{3}$$

X_i and X_j denote the location of i and j respectively. Bibliometric maps have two dimensions and rely on the Euclidean distance.

For the purposes of this study, we mainly used text mining functionality for constructing co-occurrence networks of terms extracted from metadata.

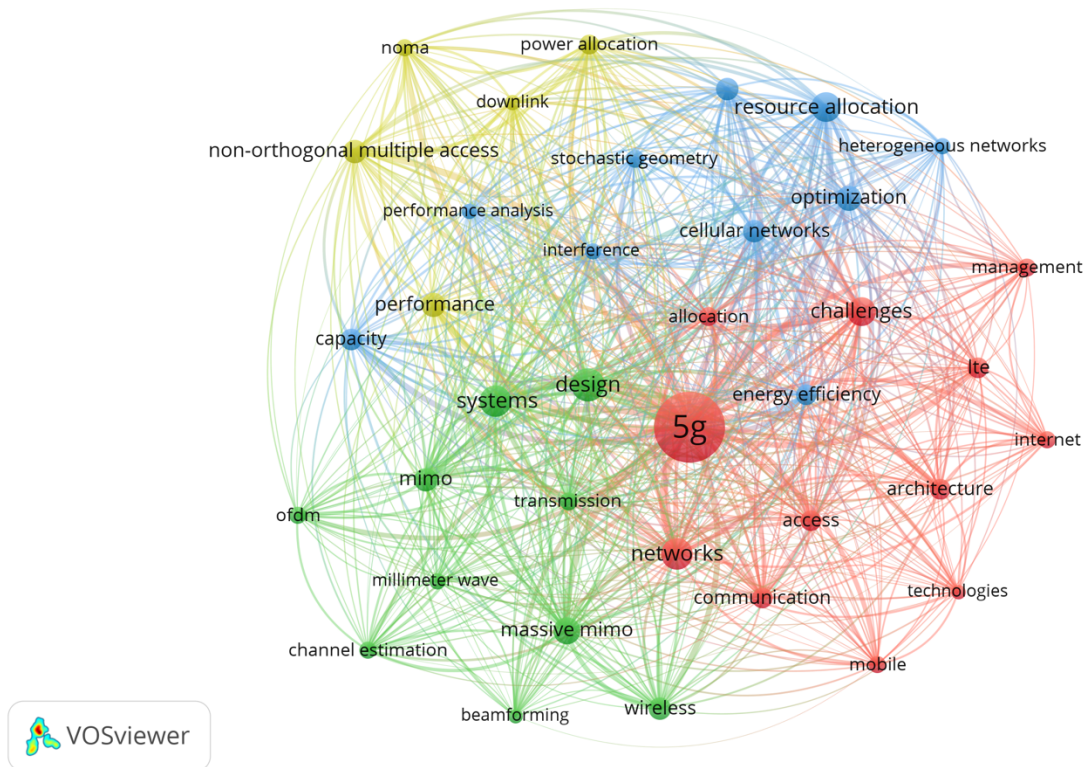


Fig. 2.2. Co-occurrence analysis of 5G-related publications. Data source: Clarivate Analytics Web of Science®. Built with VOSviewer®.

The red cluster covers general issues of 5G network management, including network architecture, green - radiotechnological aspects of network functioning, yellow - management of network power parameters and the blue one relates to optimization of resource allocation. However, the picture would be incomplete without the patent landscape because scientific inventions enter everyday life precisely through intellectual property objects and their commercialization.

Patent landscapes are a widespread tool for analyzing the evolution of technological fields and identifying hot topics [2]. Patent landscapes (also Patent Landscape Reports (PLRs) enable informed business&technology decisions [13]. However, there is no single definition of the patent landscape; it could be an overview of patent information for a specific technology or geographic area. The landscape usually strives to answer specific practical questions and present complex information about patenting activities in a transparent and intelligible form. Industry has long used the patent landscapes to make strategic decisions about investments, research and development (R&D), and competitors.

Högskolan i Halmstad. & Niamba (2016) provide a good overview of patent indicators, subdividing them into four categories [5]:

- Performance indicators deal with the patent output of the analyzed entities (inventors or applicants) that are used to monitor the technological performance of companies/institutions and inventors/researchers [10].
- Technology indicators analyze patent classifications, classifying each patent into one or more classes according to its technology area.
- Patent value indicators give an idea of the economic value of a project, which is determined by various factors such as family size, citation, and geographic coverage.

- Collaboration indicators provide information about collaboration patterns between entities.

Technology benchmarking is used to compare the performance of organizations in terms of technology applications. Benchmarking focuses on analyzing your own processes and then comparing your own performance with the performance of others [8]. Patents are reliable KPIs for comparison [6]. At the same time, patents are a lagging indicator of the company's research, since it is at least 18 months old (most patent offices around the world have a secrecy period of 18 months).

In 2011, a new technology benchmarking methodology based on patent information [3] was presented. The main indicator in this methodology is the *Patent Asset Index*, which is constructed based on the 'portfolio size', 'market coverage' and 'technology relevance' metrics. 'Market coverage' is a measure of the extent of patent protection in global markets. 'Technology relevance' is a citation-based indicator to assess the technological impact of patents, which eliminates systematic distortions of existing citation-based patent indicators. Authors argued that the Patent Asset Index offered a more accurate assessment of a firm's patent than other similar methods. We used this technique in our research, so we describe it in more detail in the next section.

3. DATA AND METHODS

The study used data on 4069 patent families associated with 5G technology. The search was carried out using the keywords "5G" and "fifth generation" with a filter by domain (IPC) H04W (WIRELESS COMMUNICATION NETWORKS [2009.01]). Patent family is a set of patents obtained in different countries for the protection of one invention (when the first application in the country - priority - then extends to other patent offices) [11, p.60]. The data source is *PatentSight*® ("Patent Research and Analytics Products | LexisNexis PatentSight®," n.d.) from *LexisNexis*. This tool provides objective metrics of global technological power and influence, developed by German scientists headed by N. Omland and H. Ernst [3] (Fig. 3.1).

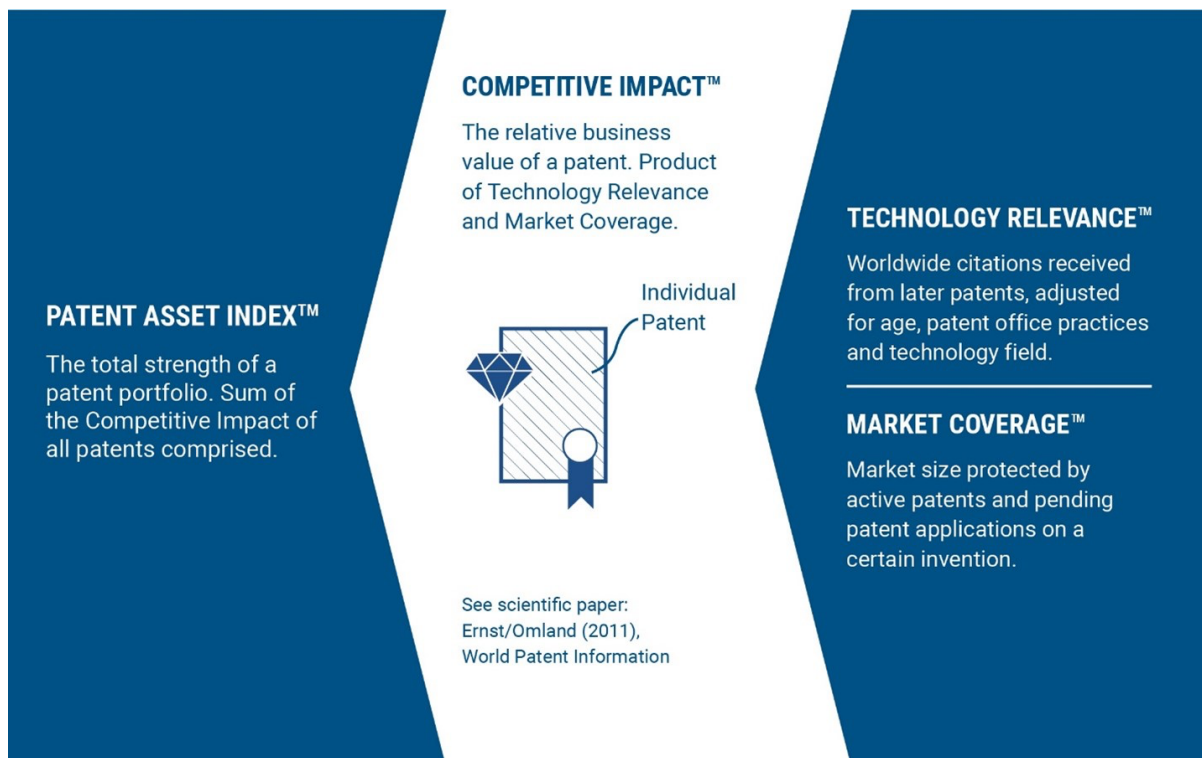


Fig. 3.1. The Patent Asset Index structure. Source: [12].

The Patent Asset Index™ (PAI) takes into account both the quantity of actively protected inventions and their quality. The method was developed and tested in scientific research and has been used by leading companies in many industries for several years. The Patent Assets Index is the overall strength of the patent portfolio. It is based on the *Technology Relevance*™ and *Market Coverage*™ of the company's patents to analyze the competitive impact of a portfolio.

Technology relevance is the worldwide citation derived from later patents, taking into account age, patent office practice, and technology area. Market coverage is the size of the market protected by active patents and pending patent applications for a particular invention. Finally, *Competitive Impact*™ measures the strength of an individual patent, i.e. the relative commercial value of the patent.

4. RESULTS

Fig. 4.1 presents the analysis of portfolio size, Patent Assets Index, and competitive impact or relative business value. The undisputed market leader is *Samsung Electronics*, which has the largest 5G patent portfolio with the highest Patent Assets Index. The other side of the coin is the low portfolio selectivity. At the same time, we observed two companies with small patent portfolios, but extremely high value (*AT&T* and *INTERDIGITAL*).

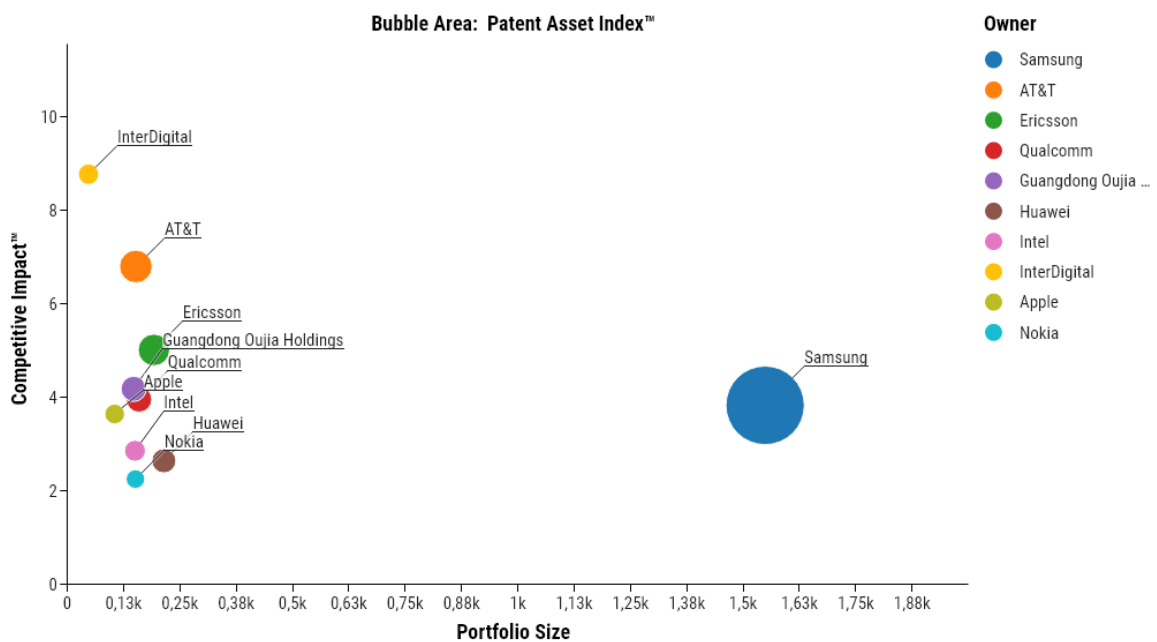


Fig. 4.1. Portfolio Size (horizontal axis), Competitive Impact (vertical axis), and Patent Assets Index (bubble size). Created with PatentSight®.

Samsung leads not only in the area as a whole, but in all sub-areas (level 4 of the IPC classification) (Fig. 4.2).

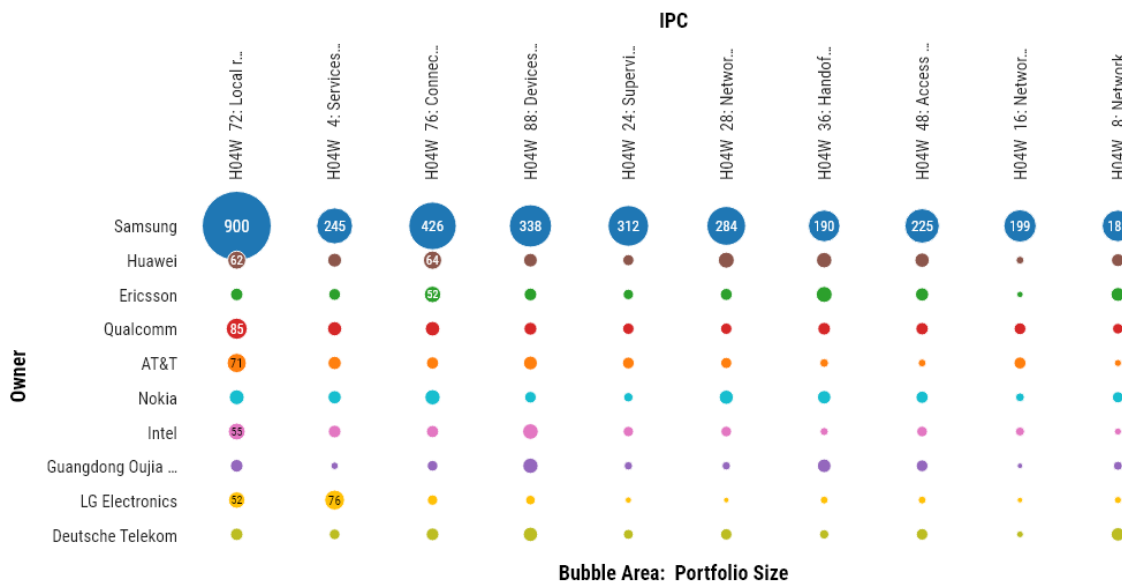


Fig. 4.2. The size of the patent portfolio by level 4 of the IPC classification. Created with PatentSight®.

However, if we look at the indicator of technological relevance, then we will not see companies with the largest patent portfolios in the list (Fig. 4.3). Often, the most cited patents appear in small tech companies or as a "by-product" of other businesses (eg Toyota).

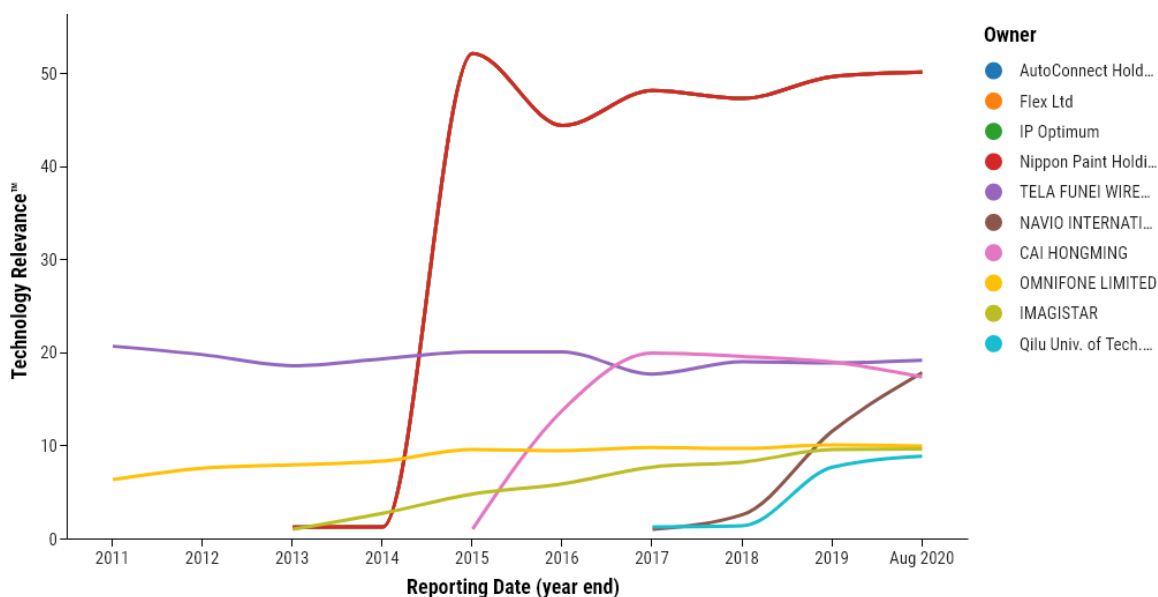


Fig. 4.3. Technological relevance of the patent portfolio. Created with PatentSight®.

Finally, in terms of the origin of patent families, two jurisdictions are leading by a noticeable margin - USA and the PRC (Fig. 4.4).

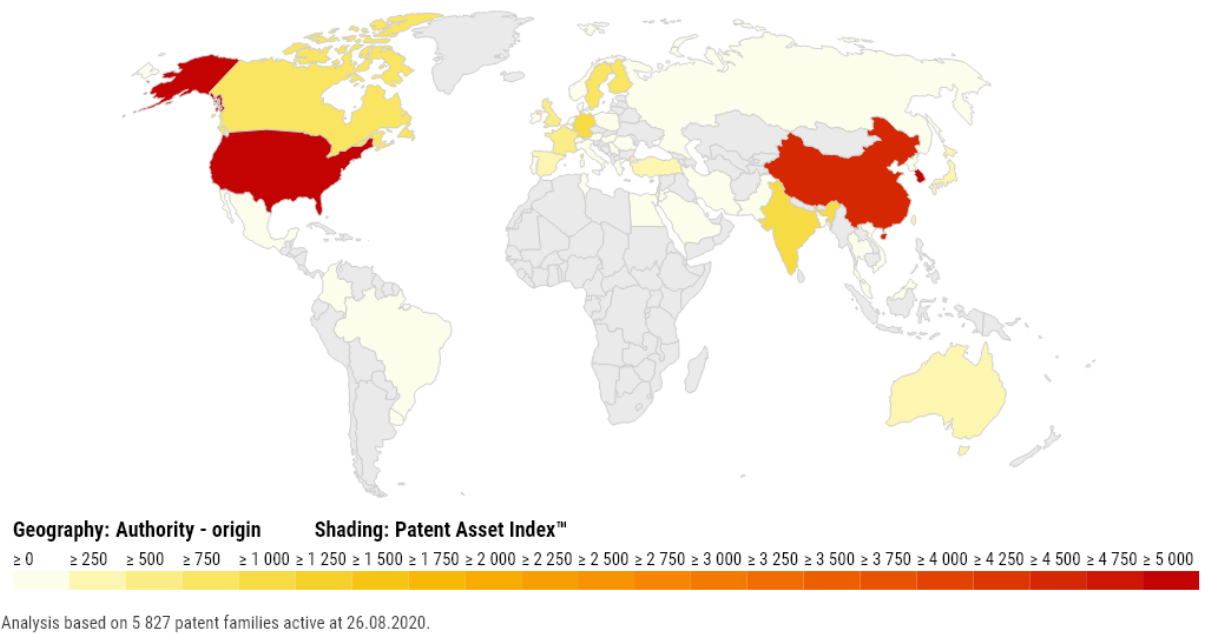


Fig. 4.4. Geographical breakdown of patent families by jurisdiction of origin. Created with PatentSight®.

5. CONCLUSION

Patent Landscape Reports (PLR) have long been used in business, science and R&D. They enable data-driven decision making and minimizing the risks of strategic technology choices. In this study, we analyzed the patent landscape for 5G wireless networks. Among the companies, the clear leader by the Patent Portfolio Index is Samsung Electronics; among countries, it is USA and China. However, patents of high technological relevance and/or commercial value may appear in small tech companies, or as a ‘by-product’ of other corporate activities.

The analysis shows that the 5G family of technologies has entered a phase of maturity, i.e. further developments will be incremental. At this stage, the market is already formed, the emphasis is shifting to commercialization and implementation. The new generation of mobile communication systems is already here [4]. However, the new generation of communication networks (6G) will be built on the existing scientific groundwork related to understanding both target applications and the most promising candidate technologies. Historical analysis of technology development based on scientometric analysis and patent landscapes enables making informed strategic decisions for technological breakthroughs in the future.

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