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# Technological research in the EU is less efficient than the world average. EU research policy risks Europeans' future

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ABSTRACT

We have studied the efficiency of research in the EU by a percentile-based citation approach that analyzes the distribution of country papers among the world papers. Going up in the citation scale, the frequency of papers from efficient countries increases while the frequency from inefficient countries decreases. In the percentile-based approach, this trend, which is uniform at any citation level, is measured by the $e_p$ index that equals the $P_{top\ 1\%}/P_{top\ 10\%}$ ratio. By using the $e_p$ index we demonstrate that EU research on fast-evolving technological topics is less efficient than the world average and that the EU is far from being able to compete with the most advanced countries. The $e_p$ index also shows that the USA is well ahead of the EU in both fast- and slow-evolving technologies, which suggests that the advantage of the USA over the EU in innovation is due to low research efficiency in the EU. In accord with some previous studies, our results show that the European Commission's ongoing claims about the excellence of EU research are based on a wrong diagnosis. The EU must focus its research policy on the improvement of its inefficient research. Otherwise, the future of Europeans is at risk.



## 1. Introduction

Production and cost analysis plays a central role in the management of all productive systems, because it is the starting point for obtaining better and more profitable products. Research is also a productive process, for which production and costs should likewise be analyzed in order to improve its societal benefits. However, there are multiple examples of countries' research policies that are established without any production and cost analysis, either on the assumption that research is always profitable or taking for granted conclusions about its output that have never been demonstrated. The most remarkable case of the latter is the research policy of the EU.

For a long time, it has been held that the EU's technological weakness lies in its inferiority in transforming scientific breakthroughs and technological achievements into industrial and commercial successes; this has been known as the "European paradox" (European-Commission, 1995). The basis for this proposal is that EU's research is excellent and that the EU leads the world in scientific breakthroughs and technological achievements. This assumption of excellence has been the basis of EU research policy from 1995 through to the current EU research framework program Horizon 2020 but, surprisingly,

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research policy makers in the EU have never demonstrated the existence of such an excellence. In contrast with this political assumption, many academic publications have demonstrated that the proposed excellence of scientific research in the EU is highly questionable or in fact inexistent (Albarrán, Crespo, Ortuño, & Ruiz-Castillo, 2010; Bonaccorsi, 2007; Bonaccorsi, Cicero, Haddawy, & Hassan, 2017; Dosi, Llerena, & Labini, 2006; Herranz & Ruiz-Castillo, 2013; Rodriguez-Navarro & Narin, 2017; Rodríguez-Navarro, 2016; Sachwald, 2015).

Currently, two main documents have been produced to give support to the new EU research program that will substitute for Horizon 2020: the "Interim Evaluation of Horizon 2020" (European-Commission, 2017a) and the "LAB-FAB-APP – Investing in the European future we want" (European-Commission, 2017b). In these documents, the "European paradox" is not mentioned, but the assumption of the excellence of the EU research is identical to which has always underpinned the idea of the "European paradox." Although it is well known that innovation goes beyond science and technology, and that incremental innovation might occur independently from basic research, for breakthrough innovation at the leading edge of knowledge, research is crucial (e.g., Leydesdorff, 2010; OECD, 1996). Therefore, it is highly worrying that the European Commission continues to apply a research policy that ignores academic findings, which indubitably demonstrate the weakness of EU research.

One factor that might explain the reluctance of the European Commission to accept the academic findings could be the complexity of academic approaches. To solve this problem a recently developed approach based on the well-established percentile apportionment method (Bornmann, 2013; Bornmann, Leydesdorff, & Mutz, 2013; Waltman & Schreiber, 2013) uses two simple indicators which are obtained by analyzing the distribution of country papers among the world papers (Brito & Rodríguez-Navarro, 2018). Going up in the percentile scale, the frequency of papers from the more research-active countries increases while the frequency from the less-active countries decreases. The trend of this frequency is uniform at any citation level and is measured by the first indicator used in this study, the $e_p$ index (see Section 3). The second indicator, $P'_{top\ 0.01\%}$, estimates the likelihood for a research system to publish very highly cited papers (Brito & Rodríguez-Navarro, 2018). Although the $P'_{top\ 0.01\%}$ indicator estimates the frequency of infrequent events, it is calculated attending to the distribution of all publications, which includes the lowly cited ones that are the most numerous in all research systems.

By using these two new mathematically based indicators, this study aimed to answer the question of whether research in the EU is excellent, as proposed by the European Commission, or weak, as proposed by several academic publications. Furthermore, we centered this study on technology, performing bibliometric searches on the research topics that support technological advancements in the forefront of knowledge.

## 2. Metrics of research excellence

The question addressed in this study is whether the research excellence of EU research that is assumed by policy makers is actually true. Since 1995, when the existence of a "European paradox" was proposed (European-Commission, 1995), a large number of documents from the European Commission have praised the excellence of EU research. This praise continues in two current documents that are important for future EU research policy (European-Commission, 2017a, 2017b). In these documents, the number of sentences or paragraphs referring to research excellence that could be recorded is very large. However, this continuous application of the term *excellence* to research takes place without reference to any definition or metric. This absence of precision seems to be a general problem: the OECD document "Promoting Research Excellence. New approaches to funding" explicitly states: "The issue of what research excellence actually is or should be about is not part of this report" (OECD, 2014, p. 21). For more information the OECD document refers to the 2012 conference "Excellence Revised" (www.excellence2012.dk, accessed 01/10/2018) where a definition cannot be found.

In scientometrics, references to excellence are very frequent (e.g., Bonaccorsi, Haddawy, Cicero, & Hassan, 2017; Tijssen, Visser, & van-Leeuwen, 2002); in 2014 there were more than 70,000 references to "research excellence" in research literature (Sorensen, Bloch, & Young, 2016). However, in most cases, excellence is associated to a fuzzy concept for which "no single indicator of excellence can be used in isolation to capture the full picture" (Tijssen, 2003, p. 95).

Consistent with this fuzzy concept, a publication from the EU's Joint Research Center entitled "Composite Indicators or Research Excellence" (Vertesy & Tarantola, 2012) reports an exhaustive analysis of 22 indicators. More recently the European Commission has reduced the number of indicators to just four (Hardeman, van-Roy, Vertesy, & Saisana, 2013), of which only the first—number of highly cited publications—is bibliometric. The usefulness of the three non-bibliometric indicators: (i) high quality patent applications, (ii) world class universities and research institutions, and (iii) high prestige research grants, is not clear because they are related to or dependent on the bibliometric one. Thus, the relation of high quality patents and highly cited papers has been demonstrated by Narin, Hamilton, and Olivastro (1997); it is probable that all universities and institutions research rankings take the number of highly cited publications into account; it is unlikely that high prestige research grants do not take into account the research experience of the project's authors, which correlates with the number of highly cited papers they have published. Taking these considerations together, the number of highly cited papers seems to be the most important indicator of research excellence.

Moreover, the use of the number of highly cited publications as an indicator of research excellence underlays the assumption that research excellence equates to a high scientific impact. However, although this impact may be estimated from the number of highly cited papers (Brito & Rodríguez-Navarro, 2018 and references therein), excellence implies superiority but does not indicate the magnitude of this superiority. Therefore, in most evaluations, the selection of the citation level or percentile threshold is made arbitrarily (Schreiber, 2013). In percentile-based evaluations, thresholds of 10%,