The Reversed European Paradox: do European Patents have a High Market Value but Low Impact?

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ABSTRACT

The U.S. research institutions often serve as role models for European research institutions in knowledge and technology transfer. This paper investigates the widely held belief that European technology transfer performance is inferior to that of the U.S. To explore this, an analysis of the quality of patents from leading U.S. and European universities and research institutes was done. The methodological approach involves a comparative analysis of key patent quality indicators: number of patent family members, forward citations, backward citations, and claims. Results indicate that the dominance of U.S. organizations is not as clear as commonly perceived. The study adds value by providing an additional understanding of the technology transfer landscape, challenging the assumption of U.S. superiority.

KEYWORDS

Patents, patent quality, patent valuation, public research organizations, research institutes, universities, Europe-U.S. comparison, number of patent family members, forward citations.

1 INTRODUCTION

The European paradox is a term coined to describe that Europe is strong in basic science but lags behind some other developed countries in technological applications in world markets [1], specifically in the commercialisation of scientific findings or what we call knowledge and technology transfer (KTT).

Many scholars have studied why some public research organisations (PROs) – which include universities and research institutes – are more successful in commercializing knowledge. Most of the research on university knowledge commercialization has been conducted in the U.S., often identified as pioneers in this area [2].

In Europe, most university or PROs' technology transfer offices are still young, with half of them being established after 2000 [3]. However, this is probably not the only reason why "Europe is perceived to lag behind the U.S. in converting its academic results into economic outcomes" [4]. This lag may affect the economic growth of European countries and also their global competitiveness in industries that rely on technological innovation.

The aim of this study is to contribute to existing studies which deal with different aspects of KTT in Europe, especially in comparison to the U.S. For example, Crespi et al. [1] focused on a comparison of European and U.S. academic patenting systems and discovered that there is a difference between PRO-owned and PRO-invented patents (inventions). They discovered that EU PROs lag behind the U.S. because 80% of patents with academic inventors are in the EU owned by private firms rather than PROs, and they are statistically not recognized as PRO patents.

On the contrary, this study is not focused on the quantity of the patents, such as Crespi's et al. [1], but on their quality. The top European and U.S. PROs will be compared according to the value of their patents by indicators of patent value.

The research question is: If we compare the patents of the top European and U.S. PROs by indicators of patent value, such as the number of patent family members and forward citations, are there any differences between Europe and the U.S.?

Understanding this research problem is important because the effective commercialization of scientific knowledge directly impacts economic growth and innovation. If European PROs can enhance their KTT performance, it could lead to increased competitiveness in global markets. By focusing on patent quality rather than quantity, this study aims to provide some insights into how Europe might overcome the perceived lag behind the U.S.

2 INDICATORS OF PATENT VALUE

Methods for patent valuation can be qualitative or quantitative [5]. We will focus only on quantitative and non-monetary methods, i.e., patent indicators [5]. Typical indicators are legal status, international and technological scope, number of forward citations and the existence of opposition and litigation [5]. Such valuation has many advantages: the method is fast, objective and inexpensive and can be fully automated once the valuation system is set up [5]. International scope (size of patent family) and forward citations (citations received from patents applied later) are probably the most frequent measures for assessing patent value. Patent valuation using forward citations has been increasingly used by practitioners when a patent's value has not been otherwise established [6].

*Article Title Footnote needs to be captured as Title Note
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Og et al. [7] divide patent value indicators into *ex-ante* indicators (family size, backward citations, backward references to non-patent literature, number of claims, and number of inventors) and *ex-post* indicators (forward citations).

We will consider the following indicators:

- Number of claims
- Number of patent family members
- Number of backward citations
- Number of forward citations

According to Squicciarini et al. [8], claims define the extent of the exclusive rights granted to a patent holder, as only the technologies or elements specified within these claims receive legal protection and can be enforced. Consequently, the scope of a patent's protection is determined by the number and specifics of its claims. Additionally, since patent fees typically depend on the number of claims included, having numerous claims can result in higher costs. Therefore, the number of claims in a patent can indicate not just its technological scope but also its anticipated market value: more claims often suggest a higher expected value for the patent [8].

Patent family size – the number of countries in which the same invention is patented – is a very important indicator of patent quality [9]. Due to the expenses associated with obtaining patents in various regions, patent holders typically choose to protect their most valuable inventions internationally. Besides considering raw family size, such as in this case, one variation of this method is to look at triadic patents, which cover an invention in the three principal markets: the U.S., Japan, and the European Patent Office (EPO). Alternatively, transnational patents, defined as patent families with at least one filing with the EPO or under the Patent Cooperation Treaty (PCT), can be considered [10].

Backward citations reveal the prior art or existing knowledge that a new patent builds upon. They are added by patent applicants, examiners, and also by third parties (e.g. during opposition proceedings), and are often used as measures of knowledge transfer [11]. A patent with numerous and relevant backward citations indicates that the patent applicants or inventors or attorneys and examiners conducted a comprehensive search of prior art. Such patents may also be less vulnerable to legal challenges and can be protected from being invalidated due to overlooked prior art. Additionally, if a patent references foundational and high-impact prior patents, it suggests that the patented invention is building on well-established and important technology, potentially indicating a higher-quality patent.

Forward citations are commonly used to measure the technological impact of innovation [11]. We can say that this indicator is the most understandable to us, as we are already familiar with it from scientific articles: when later patents quote an earlier one, it suggests that the earlier patent has contributed to new developments in the field. The more forward citations a patent receives, the more significant its impact on subsequent technological improvements.

Among these four indicators, the two most important can be considered: 1) patent family size for reflecting the potential commercial success of an invention and 2) forward citations, which indicate the technological/scientific impact of the invention.

3 METHOD

For this study, the first methodological question was, how to determine the most important or innovative European and U.S. PROs.

For the U.S., the Heartland Forward's report (2022) was used [12]. From this report, five top PROs were chosen:

- Carnegie Mellon University
- University of Florida
- Columbia University
- Stanford University
- Harvard University

For Europe, the European Research Ranking list (2020) was used [13]. From this list, five top PROs were chosen:

- Centre National de la Recherche Scientifique
- Fraunhofer Gesellschaft zur Foerderung der Angewandten Forschung E V
- Commissariat a L'energie Atomique
- Eidgenoessische Technische Hochschule Zuerich (ETH)
- University Of Copenhagen

Additionally, two not listed here PROs from Reuters' Top 100 report (2019) were selected [14].

For the U.S.:

- Massachusetts Institute of Technology (MIT) which was ranked at the world's second place in this report.

For Europe:

- KU Leuven (which was the top rank in Europe and took seventh place on the Reuters' Top 100 report).

To access indicators of patent value for these selected PROs the Orbis Intellectual Property database (Orbis IP) was used. Orbis IP contains over 145 million patents linked to detailed company information and ownership structures [15].

Excel was used to sort the data and draw the chart, and the open-source program JASP was used for statistical analysis. We used the Student's t-test (also called T-test) to compare the means between two groups [16], in the presented case, Europe and the U.S.

4 RESULTS

From the selected institutions, we can first notice that in Europe, there are three research institutes listed and three universities, while in the U.S., there are five universities and only one research institute.

Figure 1 below shows that selected European PROs outnumber the U.S. PROs in patents in the last at least 65 years. However, since there are no reliable and comparable data about these organisations' date of establishment, size and income (which can all affect the presented number of patents), it is not possible to make any comparisons or conclusions.

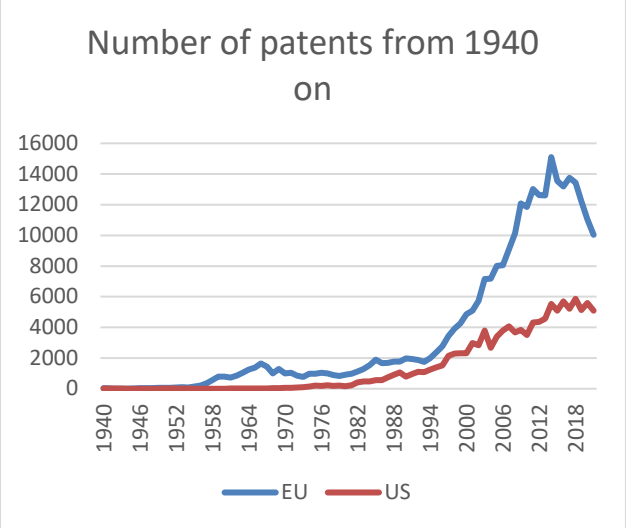

Figure 1: Comparison of no. of patents of current top PROs from 1940 on

Moreover, for the answer to the presented research question the past is not so important as in the current situation. Therefore, patents from these organisations only from the last ten years were selected, i.e., from 2014 on.

In Table 1 below, we can see the results of the T-test. All the differences in means are statistically significant ($p < 0,05$). Descriptive statistics in Table 2 show us that U.S. PROs are better than European in the number of claims and backward and forward citations. However, European PROs are better than the U.S. regarding the number of family members.

Table 1: Comparison of European and U.S. PROs (patents from 2014-2024)

Independent Samples T-test			
	t	df	p
Number of claims	-91,101	162668	< ,001
Number of family members	16,447	162668	< ,001
Number of backward citations	-40,025	162668	< ,001
Number of forward citations	-55,886	162668	< ,001

Table 2: Group descriptives (patents from 2014-2024)

	Group	N	Mean	SD	SE	Coefficient of variation
Number of claims	Europe	112918	14.082	13.774	0.041	0.978
	U.S.	49752	23.823	29.331	0.131	1.231
Number of family members	Europe	112918	10.099	18.835	0.056	1.865
	U.S.	49752	8.610	10.977	0.049	1.275
Number of backward citations	Europe	112918	3.027	9.733	0.029	3.215
	U.S.	49752	6.789	27.966	0.125	4.120
Number of forward citations	Europe	112918	0.806	3.649	0.011	4.526
	U.S.	49752	2.960	11.729	0.053	3.962

A closer look at individual PROs' patents reveals considerable differences between them. In the number of claims, MIT is the leading PRO with an average of 28 claims. In the number of family members (Table 3), Fraunhofer is the leader (with a mean of more than 17 family members), followed by KU Leuven (with more than 11 family members). PRO with the highest number of backward citations is MIT again, but the leading PRO in the number of forward citations (Table 4) is Carnegie Mellon University, with a mean of 4,18. The best European PRO in the number of forward citations is ETH, with a mean of 2,42.

Table 3: Descriptive statistics - Number of family members

	Atomique	Carnegie	Center National	Columbia	Copenhagen	ETH	Florida	Fraunhofer	Harvard	Leuven	MIT	Stanford
Valid	35282	2860	34168	8196	1427	26	10191	37257	236	4758	15640	12629
Mean	**5,035**	**4,144**	**7,328**	**8,590**	**8,473**	**9,846**	**6,076**	**17,335**	**11,169**	**11,387**	**9,539**	**10,481**
Std. deviation	3,680	4,733	7,298	10,217	9,001	7,412	6,777	29,953	11,778	15,114	13,095	11,641
Minimum	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Maximum	48,000	29,000	147,000	130,000	44,000	22,000	52,000	300,000	93,000	74,000	106,000	78,000

Table 4: Descriptive statistics - Number of forward citations

	Atomique	Carnegie	Center National	Columbia	Copenhagen	ETH	Florida	Fraunhofer	Harvard	Leuven	MIT	Stanford
Valid	35282	2860	34168	8196	1427	26	10191	37257	236	4758	15640	12629
Mean	**0,849**	**4,180**	**0,629**	**2,319**	**0,800**	**2,423**	**1,947**	**0,871**	**0,915**	**1,251**	**4,102**	**2,543**
Std. deviation	3,246	11,998	2,583	9,115	3,238	8,339	6,242	3,593	8,873	9,209	16,149	9,815
Minimum	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Maximum	162,000	260,000	117,000	232,000	53,000	41,000	181,000	126,000	130,000	396,000	410,000	259,000

5 DISCUSSION AND CONCLUSION

Results of this study show something quite the opposite of the European paradox, which suggests that while European scientific performance is on par with its main international competitors, Europe lags behind in converting research results into innovations and gaining a competitive advantage [17]. European

paradox is a term that describes Europe's strength in basic science but its perceived lag in technological applications in the global market (for example, compared to the U.S.).

In this study, the top European and U.S. PROs were compared. Results show that the U.S. top PROs are much stronger in the scientific performance of their patents: in the last ten years, an average patent from top U.S. organisations received 3 forward citations while a patent from top European organisations received only 0,8. Therefore, the scientific or technological influence of U.S. patents is more than three times higher than that of Europe.

On the other hand, European PROs demonstrate larger patent families than those of the U.S., which indicates a stronger emphasis on protecting intellectual property across multiple jurisdictions and, thus, also a broader market potential for patented inventions. That said, European inventions are much more focused on commercialisation or "competitive advantage".

U.S. PROs are also better than Europe's in the number of claims and backward citations, but these indicators may not be so important for commercial and scientific/technological success.

To help European PROs improve in terms of the number of patent claims, as well as backward and forward citations, and reduce the gap with the U.S., drafting patents more carefully with more detected prior art can be suggested. This will result in more backward citations of a particular patent and also in forward citations of quoted patents. It is also important to encourage collaboration between different PROs and between PROs and industry. Partnerships can create more comprehensive and impactful patents that include more claims and are more frequently cited.

In conclusion, while the study highlights significant differences between European and U.S. PROs in terms of patent performance, it also points to areas where European PROs can enhance their impact. Future research should focus on investigating the underlying factors contributing to these disparities, particularly by examining how patent drafting practices, collaboration networks, and industry linkages affect patent quality and citation rates. It should also be noted that this study referred to the top six PROs from each continent, and different results might have been obtained if all PROs were considered. But in any case, a methodological approach which can combine quantitative analysis of patent metrics with case studies of successful collaborations could provide deeper insights into the mechanisms that drive patent performance. Additionally, exploring policy interventions and strategies to strengthen technology transfer offices and foster innovation ecosystems in Europe could offer actionable solutions to close the gap with the U.S. The U.S., on the other hand, may close the gap with Europe by filing and enforcing its patents in more countries.

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