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The Evolution of Corporate Science in Europe: Characterizing Publication Patterns and Scientific Novelty

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Abstract: Corporate Science (CS)—the study of how firms conduct scientific research—has been a growing field of research. Nonetheless, there still persist a significant bias in terms of geographical area, with most studies centering on the U.S. scientific- Industrial complex (Rotolo et al., 2022). Furthermore, there has been little research on the characteristics of the publications themselves, beyond classical citation-based metrics. With our study we aim to first, reduce the geographical gap by characterizing and establishing a set of stylized facts on the evolution and current state of CS in 27 European Union member states, and second, we obtain empirical evidence on the degree of novelty displayed by these publications. In order to achieve this, we build a comprehensive dataset of publishing European corporations and match it with their corresponding publications, which we latter enrich with patent and bibliometrics data. We aim to contribute to the growing literature of

Corporate Science research by providing evidence of whether the apparent decline is a U.S. only phenomenon or a global trend (Arora et al., 2018; Simeth and Raffo, 2013), and discern how European industrial researchers contribute to the scientific community in terms of novelty.

Keywords: Corporate Science; Innovation; Novelty; European Union; Publication patterns

INTRODUCTION

Corporate Science can be defined as the phenomenon of private, for-profit firms engaging in scientific publication. Existing studies in the field have approached the phenomena from three distinct perspectives. First, descriptive studies focused on characterizing and establishing stylized facts about corporate science and publishing activity (Arora et al., 2018), for instance, the discovery of the decline of corp orate research at US based firms. A second stream examines corporate and organizational aspects behind scientific publishing (Rotolo et al., 2022) for example the finding s on how firms publish to alter previous art to gain advantages in patent races. Finally, a third stream centers on the consequences of corporate publishing (Arora et al., 2018; Sheer, 2022), for example, we now that publishing increases the firm value on financial markets. Research in this field is mostly quantitative, and often focused on US-based firms within few specific (Rotolo et al., 2022).

Overall, existing research has provided valuable empirical evidence on the economic and organizational benefits and challenges of corporate science. However, two critical aspects remain understudied. First, there is limited research on the nature of the scientific output produced by firms and its potential technological impact. While some prior work has examined the scientific impact of corporate articles (Sheer, 2022; Simeth and Cincera, 2016), they rely primarily on citation or journal-based metrics, such as total citations or journal impact factor. Other dimensions of corporate science, such as its degree of novelty or disruption (Uzzi et al., 2013; Wang et al., 2017), remain largely unexplored. Second, there is a notable lack of studies focused on non-US contexts, which neglects important regional specificities. In particular, the scarcity of empirical research on CS in Europe is unfortunate, as it could provide important insights into the dynamics behind the "European Paradox" - the observed gap between Europe's strong scientific output and its comparatively weaker industrial innovation performance.

Based on the above, this study addresses the following research questions:

- What are the key stylized facts about corporate science in Europe?
- What is the degree of scientific novelty and disruptiveness of corporate science produced in Europe?

To answer these questions, we will combine different datasets. First, we will compile a pool of articles published by European companies using OpenAlex, a free-access

scientific repository. Second, we will augment the corporate-level information with Orbis, which provides harmonized financial and ownership information, at the firm level. This will allow us to conduct an extensive parametric analysis, thus contributing to answering the first research question previously defined. Third, we will follow existing studies compute several novelty (Uzzi et al., 2013; Wang et al., 2017) and scientific disruption (Park et al., 2023; Wu et al., 2019) indicators, thus allowing us to observe the degree of novelty and disruption of corporate publications as compared to articles published by traditional academic institutions.

This study aims to advance our understanding of corporate science in three ways. First, by developing and analyzing an extensive dataset of European corporate publications, thus addressing a geographical gap in the field of CS (Rotolo et al., 2022). Second, we move beyond traditional citation-based metrics to assess the novelty and disruption of corporate scientific output. Finally, we aim to provide systematic evidence on how industrial scientists contribute to the broader scientific community in terms of scientific output.

The remainder of this paper is structured as follows. Section 2 provides the theoretical background, examining the phenomenon of CS, its antecedents and consequences, and exploring its impact beyond corporate boundaries through the lens of scientific novelty and disruption. Section 3 describes our data collection methodology and the integration of multiple specialized databases to create a comprehensive dataset of European corporate publications. Section 4 presents our (very) preliminary findings on the landscape of CS in Europe, with particular focus on publication patterns of top performing firms. Finally, Section 5 discusses our preliminary conclusions and outlines next steps for expanding the analysis beyond top performers to characterize the broader population of publishing firms in Europe.

THEORETICAL BACKGROUND

THE PHENOMENON OF CORPORATE SCIENCE

What is CS?

Scientific research serves two fundamental purposes: it advances our understanding of the world while enabling technological progress that drives economic growth (Rosenberg, 1974; Nelson, 2000). However, science's defining characteristic as a public good —being both non-rival in consumption and difficult to exclude others from using —, creates a theoretical puzzle (Nelson, 1959; Arrow, 1962; Stephan, 1996; Stiglitz, 1999): why would profit- seeking firms invest in producing knowledge that they cannot fully appropriate? Yet, a substantial portion of scientific output originates not from public research institutions such as universities or public research labs, but from private corporations Hicks (1995); Tijssen (2004).

Corporate science (hereafter CS) encompasses scientific research conducted and publicly disclosed by private firms through peer-reviewed publications, in

contrast to other R&D outcomes such as patents or trade secrets (Bush, 1945), that often use scientific research as an input. This apparent paradox between the public nature of scientific knowledge and its private production has attracted scholarly attention across multiple research domains.

The theoretical foundations of CS research can be traced to Schumpeter's seminal distinction between innovation and invention. This distinction highlighted how firms' R&D activities encompass multiple functions requiring different skills and capabilities, thus implying that some firms can gain competitive advantage through their innovative activ- ities. This idea boosted significant interest in the early 90s, examining the characteristics of firms' in-house scientific research (Gambardella, 1992; Hicks et al., 1994; Rappa and Debackere, 1992), with Hicks (1995) setting the groundwork to establish corporate science as a distinctive field of research.

CS research expanded significantly in the early 2000 (Rotolo et al., 2022), evolving into three distinct perspectives, distributed across a large array of disciplines. The first stream adopts a descriptive approach, characterizing the landscape of CS through three main lenses: i) documenting historical patterns and trends in CS output (Hicks et al., 1994; Tijssen, 2004; Arora et al., 2018), ii) analyzing university - industry intereactions (Hicks et al., 1996), and iii) examining how CS influences subsequent research and other R&D activities (Spencer, 2001; Tijssen and Van Leeuwen, 2006). A second stream of literature examines how scientific publishing affects firm performance. These studies doc- ument positive links between scientific publication and multiple performance dimensions such as firms' absorptive capacity (Cockburn and Henderson, 1998), innovation performance (Sheer, 2022), or stock market value (Simeth and Raffo, 2013). These findings help to explain firms' incentives to publish despite the appropriability challenges. The third stream examines the organizational dynamics of corporate scientific disclosure. This research mainly analyzes the organizational factors that influence firms' propensity to publish research, such as the development of certain capabilities (Simeth and Lhuillery, 2015), as well as the tensions arising between open science norms and commercial imperatives (Stephan, 1996; Partha and David, 1994). Overall, this stream helps to understand how firms can "learn" to publish and develop certain capabilities and skills to cope with the inherent apropriability challenges of CS.

Antecedents and consequences of corporate science

As previously introduced, firms' engagement in corporate publishing exhibit substantial heterogeneity, driven by differences in both capabilities and strategic choices. Publishing scientific research requires specific organizational capabilities (Simeth and Lhuillery, 2015) that not all firms can or choose to develop. Even if firms have the capabilities to perform basic research, they face strategic trade-offs between investing in scientific publication and allocating resources to other business-related priorities. To examine this variation in CS engagement, this section briefly

reviews three key aspects: first, the motivations driving firms to publish; second, how industry and firm-level characteristics shape disclosure decisions; and third, the benefits firms derive from scientific publication. Table 1 offers a summary of the below discussed findings.

Incentives for CS

There is a wide range of incentives for firms to engage in scientific research production. From an economic perspective Hicks (1995) argues that firms mainly engage in long term research in order to guide their applied research trajectories. This position, aligned with a knowledge-based view of the firm (Grant, 2006), recognizes the development of scientific research as an important avenue for firms to develop internal capabilities that can be also used to enhance other downstream activities (e.g. new product development). According to this view, corporate publishing can be viewed as an important input that shapes firms' technological trajectory and innovation capabilities, rather than an end in itself.

A second incentive to publish is more strategic in its nature. Godin (1996) suggests that firms leverage scientific publications to signal product quality and technological sophistication to stakeholders. Relatedly, Arora et al. (2021) show how firms strategically use peer-reviewed publications to establish legitimacy for the claims they make about their products or services.

Human capital acquisition and retention represents a third critical motivation for CS. As pointed out by Stephan (1996), researchers posses key capabilities that might be otherwise extremely difficult to find on the open market. Allowing corporate scientists to openly publish their findings serves as a tool to attract and retain them. This theoretical argument finds empirical support in Stern (2004) claim that scientists accept lower wages ("publication premium") when firms allow them to publish. This effect is particularly prominent for young researchers, where publication opportunities are important to develop scientific reputation, social capital, and to keep an option to return to academia (Simeth and Lhuillery, 2015).

Finally, another motivation involves using scientific publication to attract investor attention and signal firm value (Baruffaldi et al., 2024). Often, firms need to gather investors attention. In that case, scientific publications can be a useful a tool for disclosure, specially if the firm is subject to financial constrains, lower investor demand and has low proprietary costs.

More so, not all firms are equally positioned to engage in scientific research. First, not all industries are equally intensive in the use of science. At the industry level, sectors differ in their use of scientific knowledge. The intensity of knowledge spillovers (Arora et al., 2021) or the ease of legal appropriation (Simeth and Raffo, 2013) can be effective indicators of sector differences regarding the strategic importance of CS. Some areas are heavily subjected to regulatory oversight over its products, such as pharma or chemical industries, where performing scientific research it is not just a way of acquiring insights, but a necessary step

towards full commercial approval (Rafols et al., 2014).

At the firm level, specific investments might be needed to develop disclosure capabilities which, once acquired, can be employed to participate in the research community around it (Simeth and Lhuillery, 2015). These investments are implemented through specific disclosure strategies involving allocation of resources within the R&D department of the company, which can generate extra costs and conflicts by spurring rivalrous contest for resources between the different phases of research (Cockburn et al., 1999). Other factors such as firm size, foothold on the market, age and other within-firm specifications also influence the willingness to incur in these costs (Hicks, 1995)

Outcomes of CS

So, if engaging in CS can be so troublesome, and firms still do it, it might be due to the fact that they are obtaining benefits out of the practice that outweigh the potential costs, resulting in a positive return on investment (Arora et al., 2018). First off, internal science can be useful for improving inventions down the line. As stated by Deng et al. (1999) there is a positive correlation between the level of scientific intensity a company uses on its patents and market valuation. Furthermore, the integration between basic and applied research/invention within the firm considerably improves the quality of its patents, as measured by forward citations and, as stated by Sheer (2022) under the right combination of integration and specialization firms can draw upon their own internal re- search to improve their own inventions. Arora et al. (2021) also establishes that companies

get benefits from the use of science on their own downstream developments, but with the caveat that this benefit might be outweighed by increased spillovers to rival companies.

In order to leverage scientific findings on their downstream inventions, firms firstly need to understand its value. Conducting in-house scientific research not only helps through its own output alone, but also enhances firms' absorptive capacity (Hicks, 1995; Cockburn et al., 1999). This allows firms, through learning-by-doing, to understand scientific language, rules and customs, improving its ability to select relevant research and apply it more effectively (Cockburn and Henderson, 1998).

Companies can also benefit from engaging in CS through their ability to access external knowledge sources. By building ties with other research actors relevant to the firm through the scientific community, firms gains access to otherwise obscure or hidden information (Cockburn and Henderson, 1998), opportunities for collaboration with other researchers, and more novel knowledge Stern (2004).

Furthermore, corporations can use their own ability to disclose information to affect the behavior of other firms. Through strategic disclosure, the firm can modify the outcome of patent races through the modification of prior art (Rotolo et al., 2022),

although this strategy seems rather uncommon, at least on its own, and more usually used in conjunction with other IP strategies (Malva and Hussinger, 2012).

Another advantage firms might get from of their publication portfolio is higher valuation on financial markets. Simeth and Cincera (2015) performs an empirical analysis of US R&D performing firms by matching Compustat with patent and publication data, and they find a positive correlation between the publication stock of a company and market value even after controlling for characteristics of the patent stock (such as quantity or quality). Arora et al. (2018) gets similar results, although in their analysis the marginal market premium of each article declined over time severely, specially for high quality publications (as measured by weighted citations indexes).

Finally, firms are able to gain status and reputation through the prestige of publication. By going through the rigorous process of peer review, corporate scientific output is subjected to a high level of scrutiny, that once accepted, can be displayed as a symbol of past accomplishments, excellence, and leveraged to gain trust. This reputation gains can later be used through branding and advertising to support commercialization strategies, as mentioned before.

Is there a decline in CS?

In short, these three research streams have significantly advanced our understanding of CS. We now have detailed insights into how firms organize their research activities to maximize their ROIs (Sheer, 2022), and how they develop specialized capabilities for scientific disclosure (Simeth and Lhuillery, 2015). However, a central debate has recently emerged regarding current trends in CS activity. While early research documented increasing corporate publication rates (Halperin and Chakrabarti, 1987; Godin, 1996), more recent studies present different evidence about the trajectory of corporate scientific activity (Rotolo et al., 2022). Notably, Arora et al. (2018) empirically documents a sys- tematic decrease in scientific publication by US publicly traded companies between 1980 and 2016. While earlier studies had already suggested a similar declining trend (Tijssen, 2004), Arora et al. (2018) provides very comprehensive evidence about this. Their study reveal that this decline is based on two factors: a decreasing market premium for inter- nal scientific capabilities (reflected in both stock market valuations and M&A pricing), and firms' growing preference for accessing scientific knowledge through external chan- nels rather than internal production (Rafols et al., 2014). This shift suggest a profound transformation in how firms value and perform scientific research. In this respect, Arora et al. (2021) analyzes the tension between private benefits and knowledge spillovers in corporate science. Their research evidences an important trade-off: while firms obtain significant value from applying scientific knowledge to their downstream inventions, they also face increased costs when their research spills over to competitors. This spillover risk has intensified over time, thus partially explaining the observed decline in CS.

However, the claim of a decline in CS has been contested. Some studies examining different geographical and sectoral contexts present contrasting evidence that overlaps with Arora et al. (2018) period of analysis. For instance, Archambault and Larivière (2011) document increased scientific publication among Canadian industrial firms between 1980 and 2005. Similarly, Pellens and Della Malva (2018) find CS publication growth in the semiconductor industry, and Simeth and Raffo (2013) find growing CS activity among French firms across multiple sectors, with declines limited to specific industries such as pharmaceuticals and office machinery.

These conflicting findings may be due to important methodological limitations in CS research. Mainly, Rotolo et al. (2022) reveal a significant geographical bias in existing studies: 72% focus on single countries, predominantly the US, UK, and Japan. In fact, some of the most influential findings, like those made by Hicks (1995) in its seminal study, or Arora et al. (2018) hallmark research on the apparent decline of CS are exclusively observed with US data. Similarly, sectoral coverage is often narrow, with 68% of studies examining specific industries. As Camerani et al. (2023), making cross-study comparisons are very difficult due to varying approaches and coverage. Moreover, most research tend to over-represent science-intensive industries. Therefore, there is a need to develop broader and wider studies that can better capture the geographical and sector specificities related to a potential decline of CS.

Given the above, studying another region comparable in size, population and level of economic development but with its own idiosyncrasies has the potential of not only shedding light upon the field of CS research itself, but also to explain major differences in their respective innovation systems. In this respect, understanding CS in Europe is particularly crucial given the so-called "European Paradox", a persistent gap between Europe's scientific capabilities and its technological output (Dosi et al., 2006). This paradox manifests in the significant disparity between European and U.S. patent filings, despite comparable levels of scientific research output in both regions. Evidence suggests that corporate science plays a critical role in bridging scientific research and technological innovation: Sheer (2022) shows that sustained investment in CS enhances both the quality and quantity of firms' patent portfolios. Thus, differences in how European firms approach and invest in scientific research may also help to explain this paradox.

IMPACT OF CS BEYOND CORPORATE BOUNDARIES

While research on CS has extensively focused on its firm-level antecedents and benefits (see section *Antecedents and consequences of corporate science*), our understanding of how CS shapes the broader scientific and tech- nological landscape remains limited. This gap is important, given the emerging evidence that CS outputs are different from "traditional" science outputs (namely, science pro- duced from traditional institutions such as

universities). For instance, Arora et al. (2018) suggest that the decline in corporate science has been led by a reduction in high-impact publications, as measured by citation weights. However, relying solely on citation-based metrics to assess scientific impact has well-documented limitations (Wang et al., 2017). Citations capture only one dimension of scientific impact and may miss other crucial aspects such as novelty, or and paradigm-shifting potential. Given this, we suggest to explicitly explore whether there is a distinctive impact of corporate publications, not only in terms of "traditional" indicators (e.g. citations), but also in their potential to generate novel scientific contributions and scientific disruptions.

Beyond scientific impact: Novelty and Disruption

Scientific novelty and scientific disruption are two interrelated yet distinct concepts that play crucial roles in the advancement of scientific knowledge. Novelty refers to the intro- duction of new ideas, methods, or findings that significantly differ from existing paradigms or norms (Leahey et al., 2023; Uzzi et al., 2013). For instance Uzzi et al. (2013) concep- tualize novelty based on infrequent combinations of journal reference pairs, showing how unconventional knowledge combinations often lead to high-impact research. Research characterized by high novelty is more likely to achieve direct technological impact and influence subsequent scientific inquiries (Veugelers and Wang, 2019).

In contrast, disruption entails a deeper transformation that changes the foundational structures of scientific disciplines or practices (Leahey et al., 2023; Park et al., 2023; Wu et al., 2019). While novel research adds new elements to existing knowledge structures, dis- ruptive research fundamentally challenges or replaces existing scientific paradigms. This distinction is important: a paper can be novel without being disruptive (by introducing new combinations of existing knowledge) or disruptive without being novel (by challenging established theories with conventional methods).

Given this distinction, we suggest examining whether scientific knowledge produced by private firms (CS), might be related to the production of novel and/or disruptive science outputs.

Corporate Science, novelty and disruption

Research has shown that the dynamics of scientific teams play a crucial role in fostering both novelty and disruption, but the relationship is not clear. On the one hand, some studies report positive relationship between larger and / or more diverse teams and scien- tific novelty. For instance, (Lee et al., 2015) found that team size has inverted-U relation with novelty, as larger teams can bring in greater knowledge variety. Carayol et al. (2019) also found positive an effect of team size on scientific novelty.

However, other evidence suggest that certain forms of collaboration inhibit novel scientific contributions. Wagner et al. (2019)

found that international collaboration tends to produce conventional rather than novel or atypical research. While diverse teams can bring more perspectives to the production of science, authors argue that these potential benefits are suppressed by transaction costs and collaboration barriers among co-authors from diverse geographical and institutional origins. Supporting this view, Shin et al. (2022) confirm a negative effect of collaboration on novelty. The authors argue that while smaller groups often explore unconventional research paths, larger teams tend to build incrementally on established successes using more conventional research designs.

Given the above, our objective is to shed light on the relationship between corporate science, novelty and disruptiveness. Corporate research teams operate in distinct organizational contexts with hierarchies, more standardized processes, and commercial imperatives. They also work under a completely different institutional setting, as compared to academic scientists. It is therefore an open question whether the distinctive institutional and organizational aspects of CS will enhance or constraint the production of highly novel or disruptive science. On the positive side, CS settings may be closer to practical applications, which may enable corporate scientists to address unique knowledge combinations between basic science and technological problems. It may also be that corporate labs have greater resources and infrastructure to enable more disruptive research. On the negative side, the pressure to generate commercially relevant results might lead firms to pursue incremental advances over more uncertain and riskier paths. Given that novel science is more uncertain in its impact and acceptance (Trapido, 2015; Wang et al., 2017), it might be that firms' corporate structures discourage the pursue of riskier research paths.

DATA

Our study builds upon the database framework introduced by Arora et al. (2018), extending it with enhanced granularity by incorporating all European publishing firms, regardless of their size or stock market status. As illustrated in Figure 1, our data collection and integration process combines multiple specialized databases to create a comprehensive dataset of firm-level scientific activities.

DATA SOURCES AND COLLECTION PROCESS

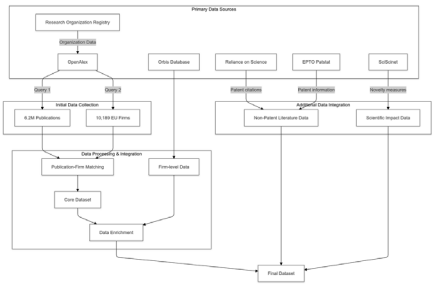
The foundation of our database, as shown in the top section of Figure 1, rests on three pri- mary data sources. The core component is OpenAlex (Priem et al., 2022), which sources its institutional data from the Research Organization Registry (ROR). ROR serves as a community-led registry providing persistent identifiers to research organizations, offering several advantages over traditional identification systems. Since its inception in 2019, ROR has facilitated bibliometric data organization across governments, research institu- tions, and platforms like CrossRef through a rigorous curation process. The registry's open-

access nature ensures regular monthly updates and thorough review of organizational changes.

Our data collection process began with two parallel queries in OpenAlex. The first query extracts 6.2 million publications with firm-affiliated authors. The second query identifies our population of interest: 10,189 EU-based firms based in EU member states. These firms are identified through ROR's geographical and institutional metadata. This approach allows us to distinguish between native EU companies and subsidiaries of foreign firms through ROR's parent-child organizational relationships. Overall, this population represents all research organizations based in EU member states that are classified as companies and have produced at least one scientific publication during their existence. This broad population is crucial for developing a comprehensive understanding of Euro- pean corporate science, addressing the geographical gap in existing literature that has primarily focused on US firms.

DATA INTEGRATION AND ENRICHMENT

Figure 1: Data collection process and dataset integration



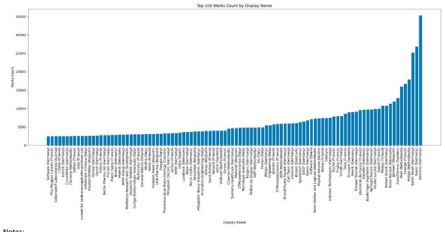
The data processing and integration phase (as displayed in the lower left section of Figure 1), involves matching publications with their corresponding firms using ROR identifiers. This matching process creates our core dataset, which we then enrich with firm-level data from Orbis, including crucial variables such as R&D expenditure, number of employees and so forth. This matching process with Orbis is particularly important, as it allows us to characterize our population of 10,189 firms along multiple dimensions, including size, age or industry classification. The integration of Orbis data is essential for our first research objective of establishing key stylized facts about European corporate science, as it enables us to analyze how firm characteristics influence scientific output and to identify patterns across different industry-level and firm-level characteristics.

Our integration strategy incorporates additional data through three main sources. We merge non-patent literature (NPL) data from the Reliance on Science database (ROS) (Marx and Fuegi, 2020) with patent information from the EPTO Patstat dataset. This combination provides a comprehensive view of how scientific publications influence techno- logical development, which will help us to examine the technological impact of EU-based CS, thus contributing to shed light to our analysis of the "European Paradox". To address the question of novelty and disruption of EU-based CS, we incorporate novelty measures at the article level from SciScinet (Lin et al., 2023). This integration aims to assess the novelty and disruption of EU-based CS beyond traditional citation-based metrics.

PRELIMINARY FINDINGS

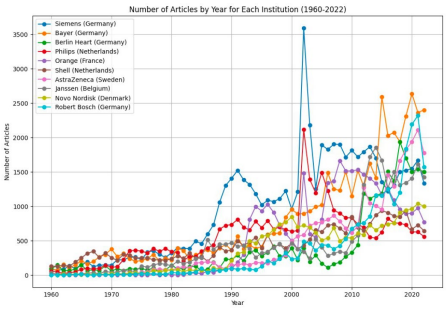
From previous literature, we have reasons to expect that the evolution and prevalence of CS at EU member states will have substantial differences with respect to the US scientific- industrial complex. Camerani et al. (2023) recently found a positive growth of CS on a worldwide dataset comprised of 2500 firms drawn from the 2014 EU Industrial R&D Scoreboard, which suggest that the decline of CS suggested by (Arora et al., 2018) might be regional rather than global. Furthermore, some suggested hypotheses to explain the difference in number of filed patents between the US and Europe argue that European firms rely less on scientific discovery as compared to their US counterparts, thus hindering their ability to develop innovations (Dosi et al., 2006). If this is the case, we could also expect lower intensity of scientific research in European corporations in comparison to US firms, given that they undervalue science on their R&D functions. Dosi et al. (2006) also points out that the capability of European firms to absorb and use scientific knowledge is lower than their US counterparts, which might also be reflected in the amount of scientific output they produce.

Figure 2: Top 100 companies performing CS in Europe



The number of firms identified through our query for EU member states differs significantly from a similar search performed only for the US, with a difference of around a 10% increase in publishing firms at the EU (around a thousand more publishing firms with respect to the US). In Figure 2 we present results for the top 100 most active European companies, based on the overall publication output. Overall, the top performer in terms of publication is Siemens, followed by Bayer, Berlin Heart and Philips, with a sharp decline in publication count after them. Some of them, like ExxonMobil (Germany) and General Motors (Poland) and more notably Janssen (Which was acquired by Johnson & Johnson in 1961) are subsidiaries of foreign firms, but results are consistent with the findings of Csomós and Tóth (2016) of high concentration of intellectual property on corporate headquarters.

Figure 3: Evolution of Top 10 CS performers in Europe



In Figure 3, we present the evolution of the top 10 performers in terms of publication counts in Europe from 1960 to 2022. Figure 3 shows a sharp increase in number of publications from 1985 onwards on most top performers, in contrast with the findings of Arts and Fleming (2018). This upwards trend is not uniform across the decades, with some firms like Siemens and Philips

peaking at the mid 2000s and then declining, and other firms such as Bayer, Bosch and Berlin Heart showing a more steady increase in their publication counts. This last company is of special note given is impressively long history of scientific output dating back to the 1700s, due to its heritage as a medical research center before becoming a turning in to a for-profit firm in the early 2000s. By sector, most of these top performers belong to industrial engineering and biotechnology, while Orange belongs to the IT sector and Shell to energy and petrochemicals.

PRELIMINARY CONCLUSIONS

Our early findings suggest that the landscape of corporate science in Europe is distinct from the US, with a higher number of publishing firms and different composition of top performers as those shown in Arora et al. (2018) and followup studies. Although our data is still in a very early stage, we find further reasons supporting a deeper analysis of the history and evolution of CS in Europe as a distinctive phenomena as compared to the US, given these differences and the potential wider implications for the European innovation system outlined in section 2.1.2. Our next steps will involve a more detailed analysis of the data, including the characterization of the firms in terms of size, age, industry and other relevant indicators, as well as expanding the analysis from only top performers to the whole dataset.

With respect to scientific impact, there has been no attempt to characterize the level of novelty and disruption of corporate publications, as compared to traditional science production. Prior studies suggest that firms are no strangers to publishing in high im- pact journals (Arora et al., 2021, 2018; Sheer, 2022), particularly those working at big centralized industrial labs. In some instances or sectors corporations have higher cita- tion impacts than universities and other public sector research entities, like biotechnology (Hicks et al., 1994; Hicks, 1995). However, the degree of novelty and disruption of such corporate produced publications remains an open question.

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