How transformative are transformative agreements? Evidence from Germany across disciplines

W. Benedikt Schmal

Suggested Citation:
Schmal, W. B. (2024). How transformative are transformative agreements? Evidence from Germany across disciplines. Scientometrics, 129(3), 1863–1889. https://doi.org/10.1007/s11192-024-04955-y

Scientometrics (2024) 129:1863–1889
https://doi.org/10.1007/s11192-024-04955-y

How transformative are transformative agreements? Evidence from Germany across disciplines

W. Benedikt Schmal[1,2]

Received: 25 August 2023 / Accepted: 20 January 2024 / Published online: 24 February 2024

Abstract
Research institutions across the globe attempt to change the academic publishing system as digitization opens up new opportunities, and subscriptions to the large journal bundles of the leading publishers put library budgets under pressure. One approach is the negotiation of so-called transformative agreements. I study the 'DEAL' contracts between nearly all German research institutions and Springer Nature and Wiley. I investigate 6.1 million publications in 5,862 journals covering eight fields in the years 2016–2022 and apply a causal difference-in-differences design to identify whether the likelihood of a paper appearing in an eligible journal increases. The effect strongly depends on the discipline. While material science, chemistry, and economics s tend to hift towards these journals, all other disciplines in my sample do not react. Suggestive evidence hints at the market position of the encompassed publishers before the 'DEAL' was established: Springer Nature and Wiley appear to benefit more from the contracts in disciplines in which they possessed a higher market share ex ante. The transformative vigor of these agreements in terms of publication behavior seems to be limited. It and highlights that the developments in this intertwined market require further examination.

Keywords Academic publishing · Open access · Transformative agreements · Publish and read · DEAL · Elsevier · MDPI · Springer Nature · Wiley

JEL Classification H52 · I23 · I28 · L13 · L86 · Z11

Introduction

Publishing research without subscription paywalls is a long-cherished dream of the scientific community (Suber, 2012). To bolster the take-up of open access, large library consortia of universities and other research institutions negotiate so-called 'transformative

✉ W. Benedikt Schmal
schmal@eucken.de

[1] Duesseldorf Institute for Competition Economics (DICE), Heinrich Heine University Duesseldorf, Universitaetsstr. 1, 40225 Duesseldorf, Germany

[2] Economic Policy Research Group, Walter Eucken Institute, Goethestr. 10, 79100 Freiburg, Germany

agreements' (TAs) that shall transform the payments streams from journal subscriptions to payments for publishing papers with open access. In contrast to setting up new fully open access journals (such as *PLoS One* in the early 2000s), these agreements create an open access option within subscription-based journals or else cover the open access option in existing hybrid journals (see, e.g., Haucap et al., 2021). Those are outlets that require a subscription but allow for the purcahse of an open access option for single articles when paid additionally (e.g., 2,890 USD / 2,290 EUR + VAT in *Scientometrics* or equivalently in plenty of other journals).[1]

The agreements constitute a significant change currently proceeding in academic publishing. Due to the ongoing digitization of research, there are others as well. Mega-journals such as the already mentioned *PLoS One* break the chains of aggregating publications to an issue: The internet neither requires space limits nor papers to be bundled to physical journals sent out via mail. Preprint servers such as the non-profit platform *arXiv*, as well as *ResearchSquare* owned by Springer Nature, or *SSRN* owned by Elsevier, disseminate research without the need for a journal. The interdisciplinary electronic science journal *eLife* switched to publishing peer reviews alongside the submissions, replacing the established back-and-forth process of reviewing, editing, and eventually publishing a widely adjusted version as the definitive one (Eisen et al., 2022).

While transformative agreements, by design, transform both payment streams and many publications from restricted to open access, I demonstrate in this analysis across disciplines that they hardly transform the publication behavior of academics in the sense that they shift their publications to eligible publishers. The topic is rather new and, therefore, not extensively studied. Nevertheless, a small body of research already exists. Borrego et al. (2021) and Moskovkin et al. (2022) study these kind of contracts in a broad sense. The former examine what exactly is understood as a 'transformative agreement' while the latter investigate the research output before and after the closure of such an agreement. Haucap et al. (2021) use causal inference methods to study the behavioral reaction to introducing the German transformative 'DEAL' agreements, but only in chemistry. Schmal et al. (2023) take another approach. They use the German DEAL agreements as well but utilize them to study gender differences in the overall publication behavior of economists.

In this paper, I study the effects of the transformative DEAL agreements between the German research institutions and the academic publishers Springer Nature and Wiley across eight academic disciplines and a residual 'multidisciplinary' category. In particular, I reexamine chemistry and economics to replicate the findings of Haucap et al. (2021) and Schmal et al. (2023). I substantially extend their work by investigating the effect on publication behavior in environmental studies, philosophy, physics, psychology, material science, and dentistry. I consider 5862 journals that published 6.1 million papers from 2016 to 2022. The central question is whether there is an increase in the likelihood of a paper being published in a journal owned or managed by the two publishers included in DEAL, Springer Nature and Wiley.

I can confirm the positive effects of chemistry and economics. In addition, I find a slightly significant effect in material science. However, there are no other significant reactions. In the subsequent analysis, I provide suggestive evidence for the substantial prevalence of null results. I discuss mainly two essential developments in academic publishing: First, the stark growth of fully open-access journals, second, the emergence of many additional transformative agreements closed between smaller consortia of German

[1] See https://www.springer.com/journal/11192/how-to-publish-with-us#Fees%20and%20Funding, last checked June 23, 2023. Fees are subject to change.

research institutions and other academic publishers. As these prominent developments do *not* seem to drive my results, I suggest that transformative agreements may trigger a 'Matthew effect' in publishing, such that the considerable DEAL agreements only affect fields in which Springer Nature and Wiley already have a prominent market position. In general, it is not trivial to net out other influential developments in the academic publishing market, such as those above, which hampers a clear-cut analysis. However, this imbroglio is by itself an important insight: Due to the plenty of initiatives attempting to reform the academic publishing market, it is difficult to purge the effects of each. This, however, makes policy evaluations more complicated.

The remainder of this paper is structured as follows. Section "The Functioning of Transformative Agreements" comprehensively sketches the contract mechanism of the transformative agreements. Section "Methods" describes the empirical methods. Section "Results" presents my findings and theoretical hypotheses as well as suggestive evidence to contextualize them. Section "Conclusion and Outlook" concludes the study.

The functioning of transformative agreements

Transformative agreements in academic publishing usually consist of a 'read' part that shall guarantee access to the existing body of research behind subscription paywalls and a 'publish' part that shall make all new submissions to the journal portfolio of a publisher fully open access for everyone.[2] Such agreements slightly vary conceptually, whether designed as a 'publish-and-read' or a 'read-and-publish' contract (Hinchliffe, 2019). Under a 'publish-and-read' regime, the publishers generate revenue only on a case-by-case basis instead of lump-sum subscription fees. For every publication, the institutions pay a fixed fee to the publisher, which also covers access to the publisher's portfolio of journals and papers. Every paper is published under an open-access license by default, and subscription fees to the covered publishers are abolished.

In July 2019 and January 2020, an alliance of nearly all German research institutions entered into such 'publish-and-read' agreements called 'DEAL' with the academic publishers Wiley and Springer Nature, which were meant to be the largest contracts of their kind back then.[3] While still having to pay submission fees, researchers do not have to administer the purchase of open access to their publications anymore but receive it free of charge and hassle. Neither do they have to apply for funding (e.g., from their institutional library or a third party), nor do they have to do any paperwork as the libraries process the billing procedures entirely in the background.[4] For the minority of journals already published fully open access by these two publishers ('gold open acces journals'), they are charged a 20% lower publication fee, which still has to be processed by the researchers individually and is not centrally billed by the clearing institutions.

The vast majority of the so-called hybrid journals allow researchers to benefit from the reputation of established outlets and free worldwide access to their research (see,

[2] See, e.g., https://esac-initiative.org/about/transformative-agreements/, last checked July 5, 2023.

[3] See the Springer Nature press release: https://group.springernature.com/de/group/media/press-releases/springer-nature-projekt-deal/17553230. Published January 9, 2020, last checked July 3, 2023.

[4] One peculiarity of the German case is that the alliance of research institutions also negotiated with the publisher Elsevier. After the failure of these negotiations, the publisher cut off researchers at virtually all German institutions from recent publications in its journals. This happened in July 2018, which coincides not directly with the start of the DEAL conditions, but still bears some simultaneity (Schmal et al., 2023)

e.g.,Schmal 2023b).[5] By and large, this led to an increase in the likelihood that a paper appears in an eligible journal in the field of chemistry (Haucap et al., 2021). As a byproduct of their research on publication behavior, Schmal et al. (2023) find a positive effect of the DEAL on eligible journals in the field of economics as well. The present paper shall broaden their findings by looking at the effect of the 'DEAL' on the likelihood of a paper being published in an eligible journal in various disciplines.

Basic economic reasoning suggests that the established hybrid journals should see a positive effect given that the outlet provides reputation, and open access may lead to a broader audience reached, which may translate into more citations. While fully open access journals suffer from the detrimental incentive to accept more papers, which, ceteris paribus, should lead to a lower quality of the marginally accepted paper, and, in turn, of the average quality, (McCabe & Snyder, 2005), open access to established journals that do not rely directly on the revenue generated by the publications should not cause the acceptance of weaker submissions as long as they continue to generate subscription revenues from other countries or institutions. At least, the incentive to do as in the fully open access case should be smaller. For example, Elsevier claims for the influential 'economics of science and innovation' journal *Research Policy* that it has no impact on peer review or the chances of a paper being accepted whether one chooses restricted or open access for the paper at the beginning of a submission.[6]

Methods

I assemble a dataset of academic publications from 2016 to 2022 covering eight disciplines: Environmental studies, philosophy, physics, psychology, material science, chemistry, dentistry, and economics. For chemistry, I use the data from Haucap et al. (2021) and add the publications for 2021 and 2022 that have not been part of their study. For economics, I use the data of Schmal et al. (2023), who have gathered data for this discipline and adjacent overlapping fields such as finance, management, and economic policy. I retrieve all publication records from the Scopus database using the Python library 'pybliometrics' of Rose and Kitchin (2019). My sample encompasses 6,125,687 observations consisting of articles and reviews; these two paper types (other than, e.g., editorials or comments) are the only types that fall under the DEAL conditions and count for the vast majority of publications. The papers have been published in 5,862 journals that are assigned to the disciplines as Table 1 displays. The number of papers per journal varies a lot across fields. In philosophy, a journal includes only a few publications. Physics, in contrast, is a field that hosts many 'mega journals' that publish thousands of papers each year.

I have selected the disciplines by two criteria: The number of journals should be narrow enough and manageable. Second, I want to cover various types of fields. For example, philosophy represents the humanities, dentistry the medical sciences, environmental studies represent earth sciences, material science and physics shall broaden the analysis of natural sciences. Psychology represents life sciences as well as social sciences, the latter together with economics. To obtain lists of relevant journals, I have used the Scimago database. It

[5] Note that there exists in parallel the alternative of 'green' open-access, i.e.e, the option that a researcher publishes their work in a restricted access journal but also shares it an a freely accessible repository.

[6] See the open-access instructions for *Research Policy* https://www.elsevier.com/journals/research-policy/0048-7333/open-access-options, last checked July 18, 2023. However, the overall claim that hybrid journals do notface the pressure to accept more papers has become the subjedct of a recent debate.

is a challenging task as journals are often related to several disciplines,[7] The matching is even fuzzier in social sciences and humanities. Table 1 details the paper count by field. Table 11 in Appendix 1 also shows the number of publications per year. One can see a steady increase from 2016 to 2022 with a decrease in 2021, probably due to the disruptions of the COVID-19 pandemic that had many direct and indirect effects on the productivity of researchers (Fischer et al., 2022; Abramo et al., 2022).

Table 12 in Appendix 1 displays the share of publications with a corresponding author from Germany.[8] It ranges from 2.31% in material science to 5.59% in economics and adjacent fields. The total share of publications with German corresponding authors is 3.31%. The number is lower than the share of publications assigned to Germany by the SCImago Country ranking (5.22% across all fields from 1996 to 2022).[9] However, it is not entirely clear how the platform assigns papers to countries. Most likely, they count all publications with a German contribution, i.e., also publications with a coauthor from a German institution not being the corresponding author. This approach would also increase the share in my sample.

I abstain from including medicine directly due to the COVID-19 pandemic, the massive shift towards preprint servers, and distorted research and publication behavior in this discipline. Of course, the pandemic has indirectly also affected the other disciplines, but less severely than medicine (Gao et al., 2021). Instead, I use dentistry, which is much narrower and less affected by the COVID-19 pandemic, to represent a medical discipline.

Generally speaking, I obtained the data in the following way. I began with a selection of suitable fields as described beforehand. Based on that, I obtained the lists of journals assigned to environmental studies, philosophy, physics, psychology, material sciences, and dentistry. For chemistry, I use the selection of Haucap et al. (2021), and for economics, the one of Schmal et al. (2023). For the latter two disciplines, I also use the data of the two cited publications. After receiving the data from Scopus for the other disciplines, I code those publications as 'multidisciplinary' that occur in several fields.[10] However, one should be aware that with this approach, a paper published in the *Journal of Economic Psychology*, being part of the psychology and the economics dataset, is classified in the same category as a paper published in *Progress in Polymer Science*. The reader should, therefore, take the 'multidisciplinary' category with a grain of salt.

Last, I elicit the country of the corresponding author as the DEAL only applies to corresponding authors (and not any author of a paper) being affiliated with a German institution. I only need the binary distinction German/non-German. So, it is trivial to identify those papers with author groups that are entirely non-German and those that are entirely German. The distinction is relevant for publications with authors from both types of institutions. For chemistry, as said before, I rely on the data of Haucap et al. (2021) and for economics on those of Schmal et al. (2023). Regarding the remaining six disciplines, I

[7] For example, *Quantitative Science Studies* which is not part of the sample, is mapped to mathematics and to social sciences, where it belongs to the subgroups library and information sciences and cultural studies, see, last checked July 25, 2023.

[8] The beneficial 'DEAL' conditions of frictionless and free open access do only apply if the *corresponding* author is affiliated with a German institution.

[9] See for details the SCImago Country ranking: https://www.scimagojr.com/countryrank.php using Scopus data up to April 2023. Last checked July 22, 2023.

[10] For technical reasons, I cannot do that with the publications for chemistry in the years 2016-2020, for which I use the data from Haucap et al. (2021). Therefore, there may be papers in the dataset that occur in chemistry and, for example, physics. I acknowledge that this is an issue, but because I conduct most of the analysis separated by field, it should not be a major one.

Table 1 Publications and journals by field

Discipline	#Papers	Share (%)	#Journals	Share (%)
Env. Studies	862,043	14.07	944	16.10
Philosophy	98,718	1.61	652	11.12
Physics	917,083	14.9	612	10.44
Psychology	408,332	6.67	997	17.01
Material Science	785,064	12.82	591	10.08
Chemistry	1,493,148	24.38	855	14.59
Dentistry	107,135	1.75	206	3.51
Economics	198,773	3.24	975	16.65
Multidisciplinary	1,255,401	20.49	886	15.11
Total	6,125,687	100	5862	100

meticulously gather data for all observations that are coauthored by an international team with at least one author from a German institution using the Scopus database again.

Before moving on, I briefly elaborate on the corresponding author identification of Haucap et al. (2021) and Schmal et al. (2023). While the latter also meticulously gather the exact corresponding author and their country affiliation, Haucap et al. (2021) circumvent this task by using the first author as the corresponding author, assuming that the authors sort themselves by their importance and that the most relevant first author is also responsible for the correspondence. Ordering by importance or relevance is common across scientific fields (Lapidow & Scudder, 2019; Waltman, 2012). Alphabetical order declined between 1981 and 2011 (Waltman, 2012), even though Engers et al. (1999) derive that it is the only theoretical equilibrium for ordering coauthors. The literature mostly names three disciplines that deviate from the 'first author = most involved author' principle: mathematics, economics, and the subfield of high energy physics (Costas & Bordons, 2011; Waltman, 2012). As chemistry is not listed, I am confident that the approach taken by Haucap et al. (2021) is reliable, and I stick to it for this field.[11]

Econometrically, I apply a difference-in-differences design using a linear probability model to compute, ideally, the causal effect of the introduction of the DEAL agreements on the likelihood that a paper appears in a journal hosted by Springer Nature or Wiley. The dependent variable is a binary dummy indicating whether a paper appears in a journal later covered by the DEAL agreements. Here, I follow the approach of Schmal et al. (2023). I set the point of treatment at July 1, 2019, when the Wiley hybrid journals became part of the contract. Since it takes some time from submission to publication (Hadavand et al., forthcoming), the effect may not play a role initially. I also compute the effect for January 1, 2020, when the Springer Nature journals entered the DEAL, which accounts for most journals. As I set up a canonical difference-in-differences model, I abstain from decomposing the treatment effect into time windows as done in an event study. It shall strengthen the ability of my model to detect an effect since my post-treatment observations only last until the end of 2022 and any effect requires months or even years to fully unfold.

Crucially, I control for the reputation of a journal captured by its relative position within a specific discipline (e.g., the *American Economic Review* would be in the top quantile in economics). In particular, I use the SCImago Journal Rank (SJR), which measures the

[11] Note that this holds for all years up to and including 2021. For 2022, there is an exact author identification. Any differences between the two methods should be negligibly small.

academic impact of an academic outlet.[12] For higher tractability, I arrange the journals in quartiles *per discipline* to avoid varying SJR averages across disciplines distorting my findings. Such differences can be caused, for example, by discipline-specific citation habits. Suppose a discipline cites, on average, more papers than others. In that case, the total number of citations per journal should be, ceteris paribus, higher along the whole impact distribution than for other disciplines with a more parsimonious citing behavior. It leads to slightly varying quartile sizes, as shown in Table 2.

The SJR criterion increases in impact. Quartile 1 embodies publications in journals with the lowest and quartile 4 those in journals with the highest impact. The empirical quartiles deviate slightly from the theoretical size of 1/4 as they are based on the journal-level SCImago ranking. Large journals at the quartile threshold slightly distort the categorization. Given the small size of the variation, this should be negligible. The SJR quartiles are computed on the final dataset after removing observations without an SJR value and reassigning duplicates. Table 13 in the appendix provides the numbers for the raw SJR quartiles, Table B4 (in online Appendix) provides the marginal effects.

Technically, I must exclude papers appearing in journals without an SJR value. In addition, I use the one-year lagged SJR values for each journal. For example, a paper published in 2020 is assigned the 2019 SJR value of its outlet. It accounts for the submission-publication lag, as a researcher can only consider a journal's reputation at the moment of the submission and not the publication.

I also include fixed effects for the time. To do so, I use categorical variables for the month and year of a publication. In addition, I interact the treatment covariate with the ranking quartile. In total, the regression equation looks as follows. I run a separate regression for each discipline and a pooled one in which I also control for the field. This is obsolete in the field-specific regressions.

$$\mathbb{1}_i^{Publ.} = SJR_i + \mathbb{1}_i^{GER} + \mathbb{1}_i^{DiD} + \mathbb{1}_i^{DiD} \times SJR_i + T_i' + \underbrace{field_i}_{pooled\ reg.} + \epsilon_i \tag{1}$$

The dependent variable $\mathbb{1}_i^{Publ.}$ on the left is a binary indicator that turns 1 if paper i is published in a journal covered by the DEAL. Using a linear probability model, I estimate the marginal effects of the covariates on the binary dependent variable switching from 0 to 1. On the right, the covariate SJR_i captures the SJR quartile of a paper's outlet. $field_i$ is a categorical identifier for the discipline a paper belongs to and is only included in the pooled regressions that include the observations of all fields. $\mathbb{1}_i^{GER}$ turns 1 for a corresponding author from Germany and is 0 otherwise. $\mathbb{1}_i^{DiD}$ is the difference-in-differences indicator variable that turns 1 if a paper has a corresponding German author *and* has been published after the DEAL was introduced. The interaction variables consist of the already explained covariates. T_i' is a time vector containing the two covariates $year_i$ and $month_i$. As a robustness check, I replace the two separate time variables with the binary indicator $\mathbb{1}_i^T$ that captures whether a paper has been published before ($\mathbb{1}_i^T = 0$) or after ($\mathbb{1}_i^T = 1$) the DEAL became active. I provide the results for the respective regressions in Tables B7 (pooled regressions) and B5 and B6 (discipline specific regressions) in the online Appendix. Eventually, ϵ_i is the idiosyncratic error term.

[12] Many different metrics exist for measuring a journal's quality, relevance, and impact. According to Mingers and Yang (2017), the SJR criterion is highly correlated with the impact factor (0.806), the 5-year impact factor (0.835), the article influence score AIS (0.906), and the 'source normalized impact per paper' criterion SNIP (0.807). That makes me confident that the SJR is suitable for quantifying journal impact.

A crucial econometric assumption is that only the treatment group is affected by the treatment. Given that several countries have formed consortia to negotiate transformative agreements,[13] this condition is not fully satisfied in my setting. I address this in two ways. On the one hand, I assign the whole world except for Germany as a control group in my primary analysis. By construction, it assigns some countries with their own transformative agreements to the control group. Due to the large number of countries, every country only counts for a meager share of publications. Hence, the individual impact of other transformative agreements should be negligibly low. My second approach supports this: I exclude those countries from my analysis that have the highest *share* of their publications covered by transformative agreements.[14] It includes contracts with Springer Nature and Wiley but also other publishers. Due to the binary setting in my analysis, the '$1-p$' issue arises in the sense that a decision in favor of one publisher always implies a decision against any other publisher.[15] So, transformative agreements closed with publishers other than Springer Nature and Wiley might still affect the likelihood of a paper appearing in the latter two as they become mechanically weakly less attractive when agreements with other publishers are concluded.

There are 595 transformative agreements that began in one of the years 2019–2022,[16] in 42 countries and by the 'eifl' association[17] for several developing countries (even though it covers only 60 planned annual publications and is, by that, very small). Counting only contracts with more than 100 annual publications, the number of TAs diminishes to 237 contracts in 32 countries. Among the 42 countries, transformative agreements cover only in sixteen of them more than 10% of the annual publications of these countries.[18]

Table 3 displays the countries with transformative agreements that jointly account for at least 10% of a country's overall annual publication output (based on the SCImago Country Ranking). One can see that nearly all countries are located in Europe. Sweden, the Netherlands, and Hungary have the highest share of covered publications, while the United Kingdom has the highest absolute number of covered publications. Within this group, Germany has a relatively small share of only 15% of its annual publications covered. The distinctive feature is that the DEAL contracts with Springer Nature and Wiley account for nearly 2/3 of the covered TA publications in Germany (19,000 planned annual publications $\approx 64.84\%$).

Lastly, studying the situation in Germany, one has to be aware that in parallel to the introduction of the transformative DEAL agreements, the alliance of German research institutions also negotiated with Elsevier. However, both sides did not agree until 2023. Quite the opposite, most German institutions quit their subscriptions. As a consequence,

[13] Here, I use the ESAC Transformative Agreement Registry, https://esac-initiative.org/about/transformative-agreements/agreement-registry/, last updated June 30, 2023, last checked July 13, 2023.

[14] For computational ease, I apply here the 'first author identification,' i.e., I exclude a paper if its first author is affiliated with an institution in a country with its own transformative agreements. As discussed beforehand, this is slightly fuzzier than the exact corresponding author identification but should be a sufficient approximation as the first author is not only often the corresponding one but also, for the large number of papers stemming from one country, it is correct as well.

[15] This is equivalent to the $1-p$ problem in topic modeling, see, e.g., Schmal (2023c).

[16] Contract extensions are counted as separate contracts.

[17] See for information https://eifl.net/page/about, last checked July 24, 2023.

[18] To measure the annual publications of a country, I use the SCImago Country Ranking of 2019 and weight the annual number of publications (called "documents") by the annual (expected) number of publications as listed in the ESAC database. I use the year 2019 to net out direct negative or indirect catch-up effects of COVID-19 on publishing.

Table 2 Number of publications by SJR quartile

Quartile	#publications	Share(%)	Cumulative (%)
SJR quartile 1	1,536,240	25.08	25.08
SJR quartile 2	1,539,122	25.13	50.21
SJR quartile 3	1,521,019	24.83	75.03
SJR quartile 4	1,529,306	24.97	100.00
Total	6,125,687	100	

since July 2018, the publisher denied researchers from these institutions access to recent publications in its journals (Fraser et al., 2023; Schmal et al., 2023). The rift may have induced researchers from affected institutions to shift their papers to other publishers' journals, such as those having closed DEAL agreements. In a sensitivity check, I exclude publications in Elsevier journals.

Results

Empirical findings

Using a difference-in-differences design, I compute the effect of the DEAL-induced frictionless open access incentive on researcher behavior across fields. Table 4 below presents the average marginal effects (AME) of the aggregate effect of the DEAL for the treatment point at the beginning of the Wiley contract on July 1, 2019 and the Springer Nature contract on January 1, 2020 based on separate regressions. I report 95% confidence bands throughout my results. The raw number of observations is often high, especially for the natural sciences. Given that only publications from Germany after June 2019 are counted as treated, this number is much smaller, even for disciplines with many observations, as Table 14 in Appendix 1 highlights.

Looking at Table 4, the average marginal effect is insignificant and close to zero for both times of treatment. On aggregate, the DEAL apparently did not significantly change publication patterns of researchers up to now. Given that my data last until 2022, I have a treatment period of 3.5 years (3 for the Springer timing), which should have been enough time to capture existing effects even if one takes into account long turnaround times of submissions that lead to a staggered visibility of the actual effect. Thus, the result is unlikely to be driven by a too short time window.

Contrary to the aggregate result, I find notable differences between the fields when decomposing the overall effect into one for each discipline. Figure 1 presents the average marginal effect (AME) for each field using the Wiley treatment timing, Table 5 below provides the details (Table B3 in the online appendix presents the results for the Springer Nature timing). The marginal effects are computed separately for each discipline.

I detect a significant positive effect of the DEAL agreements in material science, chemistry, and economics. The latter is qualitatively equivalent to the coefficient estimated by Schmal et al. (2023).[19] Journal publications are important in virtually every academic discipline, but the field of academic economics is particularly strongly involved with

[19] The authors compute an effect size of 0.0469. It varies slightly in absolute terms due to the assignment of several journals to the 'multidisciplinary' category.

Table 3 Share of transformative agreements on total research output by country

Country	TA Pubs	Total Pubs	TA share (%)
Sweden	22,846	45,694	50.00
The Netherlands	3,1380	66,274	47.35
Hungary	5877	12,693	46.30
Austria	10,153	29,338	34.61
Norway	8481	26,115	32.48
Finland	6,821	23,400	29.15
United Kingdom	54,987	224,582	24.48
Ireland (Rep.)	3563	17,124	20.81
Spain	19,428	104,350	18.62
Slovenia	1277	7214	17.70
Switzerland	8301	50,893	16.31
Germany	29,305	195,359	15.00
Denmark	41,10	31,341	13.11
Australia	14,302	114,649	12.47
Portugal	3207	30,627	10.47
Qatar	480	4607	10.42

Displaying countries with transformative agreements starting in the years 2019–2022 and having an accumulated share by country of > 10%. Sources: SCImago Country Ranking from the year 2019 (https://www.scimagojr.com/countryrank.php?year=2019) and ESAC registry, last update June 30, 2023, see https://esac-initiative.org/about/transformative-agreements/agreement-registry/

publication strategies (Heckman & Moktan, 2020; Fourcade et al., 2015), so the additional incentive of 'free' (for the researcher) open access may play a larger role for the discipline. Interestingly, the marginal effect for chemistry amounts to 3.64%, which comes close to the estimate of +3.81% of Haucap et al. (2021) using a heteroskedastic probit model. The crucial difference between the two estimates is that Haucap et al. (2021) only study a very short time window of 1.5 years, which ends with the observations of 2020. Given that my estimate for data lasting two years longer is arguably the same, I carefully conclude that there seems to be no increase over time but more likely a single shift towards journals covered by the DEAL. It opposes the hypothesis that it takes time for the DEAL benefits to be spread among the research community. In that case, the effect should vary. Most likely, it should be higher the longer the time window lasts because more and more researchers had the chance to learn about the DEAL conditions in Germany. Lastly, material science also displays a positive take-up of the DEAL, highly similar to the effect on chemistry, but only significant on the 10% level ($p = 0.069$).

In contrast, I cannot detect any significance for the coefficients of the marginal effects in environmental studies, philosophy, physics, psychology, dentistry, and multidisciplinary publications. All coefficients are 'fully' insignificant in the sense that their p-values are not even close to any significance level. Furthermore, most of them are close to zero in absolute terms. Table 18 in Appendix 1 displays the twenty journals with the highest change in the share of publications with corresponding authors at German institutions. Five

Table 4 Average Marginal Effect on publishing in an eligible journal on aggregate

Treatment Time	AME	Std. Err.	t-statistic	p-value	95% CI	
Wiley	0.0019	0.0070	0.27	0.784	− 0.0119	0.0157
Springer Nature	0.0024	0.0072	0.33	0.741	− 0.0117	0.0165

Time of treatment: Wiley: July 1, 2019; Springer Nature: January 1, 2020. Controlling for time using year and month fixed effects. Standard Errors heteroskedasticity-robust and clustered on the journal level. N = 6,125,687. Separate regressions for the two treatment points

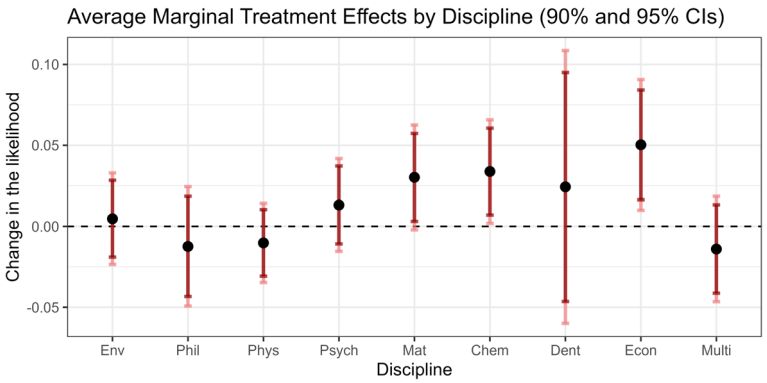

Fig. 1 Marginal effects separated by discipline. 90% Confidence bands in dark red, 95% confidence band extenseions in light red provided. Standard Errors heteroskedasticity-robust and clustered on the journal level. Each marginal effect is computed based on separate regressions for each discipline. Details on the coefficients can be found in Table 5 below

Table 5 Marginal effects separated by discipline

	AME	Std.Err.	t-stat.	p-value	95% CI		N
Env. Studies	0.0047	0.0144	0.32	0.746	− 0.0237	0.0330	862,043
Philosophy	− 0.0124	0.0188	− 0.66	0.509	− 0.0493	0.0245	98,718
Physics	− 0.0102	0.0125	− 0.82	0.413	− 0.0348	0.0143	917,083
Psychology	0.0132	0.0146	0.90	0.368	− 0.0155	0.0419	408,332
Material Sc.	0.0302*	0.0165	1.82	0.069	− 0.0023	0.0626	785,064
Chemistry	0.0338**	0.0163	2.08	0.038	0.0018	0.0657	1,493,148
Dentistry	0.0243	0.0430	0.56	0.573	− 0.0605	0.1091	107,135
Economics	0.0503**	0.0206	2.44	0.015	0.0098	0.0908	198,773
Multidiscipl.	− 0.0140	0.0166	− 0.85	0.398	− 0.0465	0.0185	1,255,401

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard Errors heteroskedasticity-robust and clustered on the journal level. Observations for each regression reported in the last column on the right. The coefficients are plotted in Fig. 1 above

of them are related to chemistry and four to economics, the two disciplines for which I find significantly positive reactions to the introduction of the DEAL.[20]

Excluding countries with their own transformative agreements

As discussed in Sect. 3, transformative agreements exist with many publishers in several countries. As Table 3 has shown, 16 countries have concluded contracts that cover at least 10% of their annual publications. In this robustness check, I exclude 15 of them (the sixteenth is Germany in the treatment group) from the analysis. Table 6 below provides the marginal effects for the regressions excluding these countries. One can see that hardly anything changes qualitatively. Quantitatively, the effects vary only slightly. As before, I can only detect significant changes in material science, chemistry, and economics. The effect for chemistry, however, is now only significant on the 10% significance level ($p = 0.067$). Hence, neither removing or including these countries substantially affects the regressions.

On the one hand, this underlines the robustness of my primary approach, which assigns all countries to the control group. In contrast, many excluded countries also closed transformative agreements with Springer Nature and Wiley. Suppose these agreements had led to a higher interest in the journals of the latter two publishers. In that case, the treatment effect for authors from Germany should have been larger than before, as the transformative agreements with the DEAL publishers in other countries would have pushed the likelihood of a paper published from authors in the control group countries upward. Thus, *excluding* them from the analysis would widen the gap between treatment and control, but if and only if the transformative agreements in the excluded countries would have had a positive effect on Springer Nature and Wiley. Even though it is limited in its explanatory power, the high number of transformative agreements in those countries seems to generate a level playing field for publishers as not only the leading ones – namely Springer Nature and Wiley – benefit from frictionless open access, since the marginal effects are not pushed upwards when excluding the other TA countries.

Economic mechanism

The large prevalence of null results across disciplines is, nevertheless, puzzling. While researchers in three disciplines take up the frictionless open access, all other fields remain inert. One potential reason for that is purely mechanical. Long lags between submission and publication of a paper may be an essential driver of the null effects. Many publications in the treatment window are likely to have been submitted before the DEAL contracts were in place. On the other hand, work submitted under the DEAL conditions may still need to be published. Thus, the actual treatment effect may be diluted by submission behavior yet unaffected as the DEAL was not in place when the authors decided where to submit their work and by submissions that did not turn into publications yet. With a longer post-treatment time window, this problem should disappear. In light of a treatment period of 3 - 3.5 years, this explanatory approach is not fully convincing. Aside from that mechanical reason, three different economic reasons are conceptually conceivable:

[20] However, one has to acknowledge that also four journals from environmental studies and four from philosophy occur. As mentioned, both do not show any reaction in total. While for the latter, a lack of statistical power is easily conceivable, this does not really apply to environmental studies.

(I) Lack of knowledge – researchers may simply have not heard about the DEAL and its benefits. They cannot acknowledge an incentive they are not aware of.
(II) The incentive is not sufficient to change publication preferences either because the eligible journals have no relevance for the researchers at all or else all journals are stellar outlets in their fields such that it does not need any further incentive to encourage researchers to submit and subsequently publish their work in the DEAL journals.
(III) The benefit is outrivaled by incentives to publish in other journals in parallel.

Regarding hypothesis (I), it is difficult to figure out to which extent researchers have been informed by their institutions about the open access advantage in Springer Nature and Wiley journals. There exists sufficient effort by many academic institutions to disseminate information on how to publish with open access. However, it is questionable how quickly this insight diffuses. A lack of knowledge stands to reason as an explanatory channel for the plethora of null effects in addition to the fact that an existing effect may not be detectable *yet*.

Hypothesis (II) claims that the incentive of frictionless open access in eligible journals does not play a role. To make this case, it is helpful to think about the two corner solutions: Either the journals of Springer Nature and Wiley are in their entirety so strong that even without the open-access incentive, every researcher in all the disciplines with null effects aims at getting their work published in a journal hosted by these two publishers. In that case, the additional open access does not change the behavior. The opposite, also in support of (II), is that all the covered journals are so weak in their reputation that additional frictionless open access does not change anything in the evaluation of the researchers. Free open access will not change their opinion if they never publish a paper in an eligible journal.

The latter corner solution is rather unlikely, given the broad spectrum the two publishers cover. According to the publishers, Springer Nature has a portfolio of more than 3,000 and Wiley of more than 1600 journals.[21] In these large sets of outlets, one will find top-, mid-, and low-tier outlets for many academic disciplines. Haucap et al. (2021) and Schmal et al. (2023) could further show for chemistry and economics & management that the journal ranges of the two publishers varies but their journals are spread across the reputation scale using the SJR criterion.

However, the former interpretation could be true to some extent. Of course, the two publishing houses do not only run top-tier but also weaker journals that may benefit from the open access incentive. On the other hand, Springer Nature and Wiley are ranked second and third in terms of annual publications after Elsevier. Thus, in many fields, they already hold strong positions. If researchers choose other publishers, this might be for a reason that overrules additional open access covered by the DEAL. Put differently, journals of Springer Nature and Wiley could already have reached their full publication potential in the sense that reasons to publish in other publishers' journals may not be challenged by frictionless open-access. The consideration that other factors may outlevel the DEAL benefit leads me to Hypothesis (III).

This last hypothesis states that other incentives may override the DEAL benefit and they were introduced in parallel to the DEAL. It corresponds to (I) in the sense that other

[21] See for Springer Nature: https://www.springernature.com/gp/products/journals, last checked July 14, 2023, and for Wiley: https://onlinelibrary.wiley.com/library-info/products/journals, last checked July 14, 2023.

Table 6 Marginal effects separated by discipline excluding countries with their own transformative agreements

	AME	Std.Err.	t-stat.	p-value	95% CI		*N*
Env. Studies	0.0005	0.0155	0.03	0.976	− 0.0299	0.0308	716,543
Philosophy	− 0.0112	0.0191	− 0.58	0.559	− 0.0487	0.0264	74,388
Physics	− 0.0140	0.0139	− 1.01	0.314	− 0.0412	0.0133	811,939
Psychology	0.0150	0.0153	0.98	0.327	-0.0150	0.0449	304,449
Material Sc.	0.0308*	0.0170	1.81	0.070	−0.0026	0.0642	710,880
Chemistry	0.0321*	0.0175	1.83	0.067	− 0.0023	0.0665	1,340,721
Dentistry	0.0178	0.0455	0.39	0.695	− 0.0718	0.1075	90,259
Economics	0.0487**	0.0223	2.18	0.029	0.0049	0.0924	146,940
Multidiscipl.	− 0.0170	0.0174	− 0.98	0.327	− 0.0512	0.0171	1,126,232

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Standard Errors heteroskedasticity-robust and clustered on the journal level. Observations for each regression reported in the last column on the right. The list of excluded countries can be found in Table 3, putting Germany as treated country aside

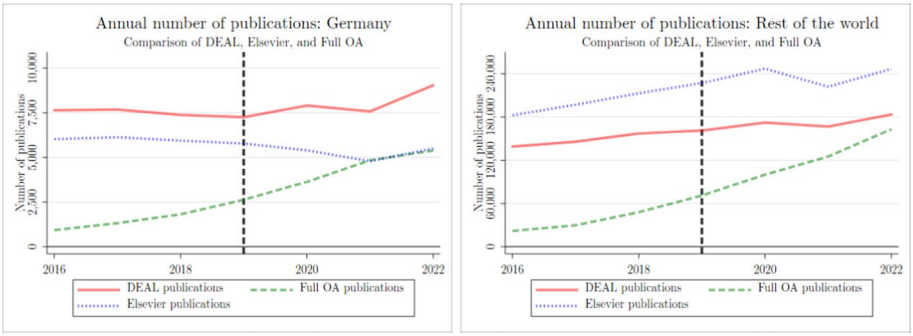

Fig. 2 Development of publications over time. The left panel plots the publications from authors with a German affiliation, the right panel those from all other authors. Full OA publications captures publications in journals of fully open access publishers. DEAL publications encompass publications in Springer Nature and Wiley journals. All three categories contain fully open access publications. Both panels show publications in the covered eight disciplines (+ multidisciplinary journals)

incentives in specific disciplines could be more present to the researchers when deciding where to submit and publish their work. The most significant transition in the academic publishing market is the general move towards open access. While transformative agreements are one step in that direction, many fully open-access journals are emerging, i.e., journals publishing every paper with open-access by default. In turn, they cannot charge any subscription fees but do charge publication fees (APCs) for every article.[22]

[22] This holds for the vast majority of so-called 'gold' open-access journals. 'Diamond' open-access publications go even one step further by publishing everything with open-access but *without* charging publication fees (Schmal, 2023a).

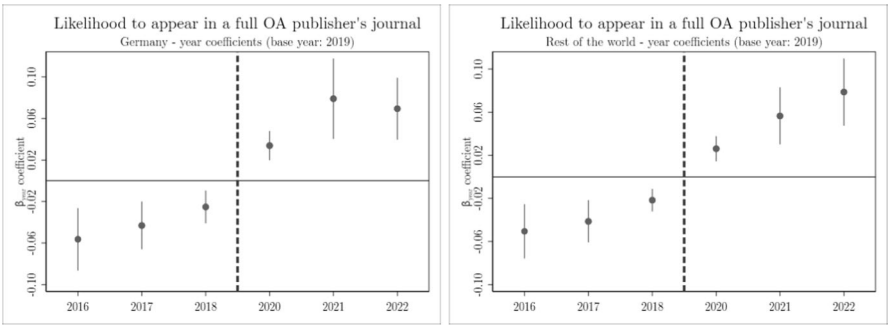

Fig. 3 Year coefficients for a paper to appear in a journal of a fully open access publisher. Dependent variable: Binary indicator whether a paper has been published in a journal of one of the following full open access publishing firms: eLife, Frontiers, Hindawi, MDPI, Public Library of Science. Explanatory variables: A set of dummies for each year as shown in eq. (1). Reference year: 2019. The dashed line in the plot marks this. Standard errors heteroskedasticity robust and clustered on the journal level. 95% confidence bands shown. $N_{LHS} = 203,055$, $N_{RHS} = 5,922,632$. LHS: Publications from Germany. RHS: Publications from all other countries. Exact estimates are shown in Tables B8 (LHS) and B9 (RHS) in the online appendix

Figure 2 gives an impression of the development of publications in my dataset over time, the left panel presents the situation in Germany, the right one the rest of the world. One can immediately see that the group of leading fully open access publishers (eLife, Frontiers, Hindawi, MDPI, Public Library of Science (PLoS); in alphabetical order) faces massive growth, while the growth rate of the DEAL publishers Springer Nature and Wiley is generally lower, the same holds for Elsevier. In Germany, the absolute number of articles in Elsevier journals was even decreasing for several years. This might be related to the conflict between the German research community and the publisher, which I discuss later on.

The growth of fully open-access publishers

Taking a different perspective on the rise of fully open access publishers, Fig. 3 displays the coefficients for the year dummies in an OLS regression that computes the likelihood of a paper appearing in a journal of a fully open-access publisher regardless of any other covariates. The coefficients are computed relative to the base year 2019, in which the DEAL started. The parsimonious setup only uses the year dummies as regressors. Hence, the equation is as follows:

$$\mathbb{1}_i^{Full\,OA} = \beta_y Y_i' + \epsilon_i \tag{2}$$

The dependent variable on the left is a binary variable that turns 1 if paper i is published in a journal of a fully open-access publisher named beforehand (i.e., eLife, Frontiers, Hindawi, MDPI, Public Library of Science). On the right, I use the vector of categorical year variables Y', which contains a dummy variable for each year. ϵ_i is the idiosyncratic error term, and I include a constant in the regression.

Especially in the most recent years, 2021 and 2022, the probability of appearing in such an outlet has significantly increased relative to the base year of 2019 in both Germany (LHS) and the rest of the world (RHS). Nonetheless, the year coefficients for the previous years, 2016–2018, are also significantly lower compared to the base year

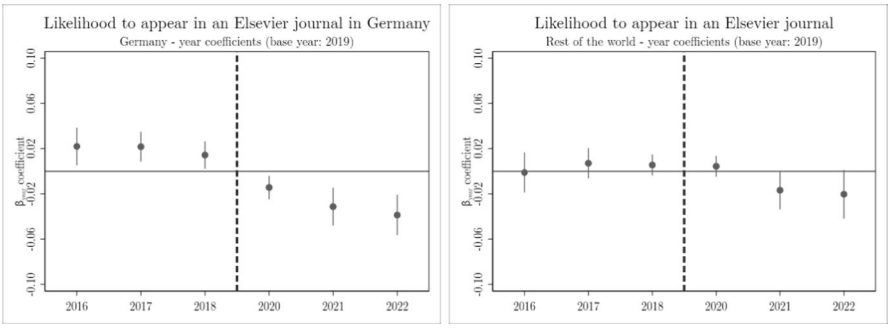

Fig. 4 Year coefficients for a paper to appear in an Elsevier journal. Dependent variable: Binary indicator whether a paper has been published in an Elsevier journal. Explanatory variables: A set of dummies for each year as shown in eq. (1). Reference year: 2019. The dashed line in the plot marks this. Standard errors heteroskedasticity robust and clustered on the journal level. 95% confidence bands shown. $N_{LHS} = 203,055$, $N_{RHS} = 5,922,632$ LHS: Publications from Germany. RHS: Publications from all other countries. Exact estimates are shown in Tables B8 (LHS) and B9 (RHS) in the online appendix

2019. Hence, the growth in fully open-access publications has taken place for quite some time. It is an additional indicator that – besides the introduction of transformative agreements – several developments in academic publishing take place, which may weaken the statistical impact of such contracts. However, it is not directly distorting my analysis as it is not restricted to the treatment phase and neither exclusive to treatment or control group, but is a sustained process.

The transformative agreements with the established publishers Wiley and Springer Nature may have been closed 'too late,' so fully open-access competitors could have already established themselves. From a competition perspective, this is important as transformative agreements like the DEAL can potentially raise the market entry barriers for new fully open-access publishers (Schmal, 2023a). However, one has to consider that in the causal-inference framework of difference-in-differences, any *general* trends towards fully open-access journals should econometrically net out. Hence, given the shift towards these journals is highly similar in Germany and the rest of the world, it should not affect my results. However, differences can arise in case the take-up of fully open-access journals developed in Germany is different to the rest of the world in parallel to the introduction of the DEAL contracts.

The German Elsevier cut-off

While the patterns of the turn towards fully open access publishers are equivalent for Germany and the rest of the world, a notable difference arises for the leading commercial publisher Elsevier. Springer Nature and Wiley closed DEAL agreements with the German consortium. Elsevier was also in negotiations, but they ultimately failed.[23] This led to a cut-off of virtually all German research institutions from recent Elsevier publications in

[23] After a new attempt was taken, the German research institutions and Elsevier concluded an agreement in September 2023, see the press release by the HRK representing the research institutions: https://www.hrk.de/presse/pressemitteilung/meldung/the-deal-consortium-and-elsevier-announce-transformative-open-access-agreement-for-germany-5006/, published September 6, 2023, last checked December 11, 2023.

Table 7 Market share of Elsevier across disciplines among publications from Germany ahead of the Elsevier cut-off

Discipline	#Elsevier.	#All.	Elsevier share (%)
Env. Studies	1816	6015	30.19
Philosophy	0	1462	0
Physics	1547	10,570	14.64
Psychology	1114	5818	19.15
Material Sc.	1710	6691	25.56
Chemistry	4410	24,668	17.88
Dentistry	106	1417	7.48
Economics	910	3429	26.54
Multidiscipl.	3407	9594	35.51

Table 8 Largest publishers by publications from German authors in physics

Publisher	#Papers	Share (%)	Cum. (%)
Springer Nature [DEAL]	4370	14.94	14.94
Elsevier	3708	12.68	27.63
American Physical Society*	3436	11.75	39.38
American Institute of Physics*	3144	10.75	50.13
Institute of Physics*	2410	8.24	58.37
The Optical Society	1577	5.39	63.76
IEEE	1239	4.24	68.00
MDPI	1141	3.90	71.90
Royal Society of Chemistry*	1116	3.82	75.72
Oxford University Press*	877	3.00	78.72
Other	6222	21.28	100
Total	29,241		

The asterisk signs publishers which have concluded transformative agreements with German consortia aside from the DEAL that are active in at least one year in 2019–2022 and cover at least 100 expected publications. Springer Nature is exempt as it closed the DEAL. Overall time window: 2016–2022

July 2018, which prevailed over the course of this study (Fraser et al., 2023; Schmal et al., 2023).

Figure 4 demonstrates that relative to the baseline year of 2019, the likelihood of a paper from a German corresponding author to appear in an Elsevier journal significantly decreased (only taking into account time variables as sketched in eq. 1). For the rest of the world, one can also see some slight negative development for Elsevier publications, but it is much less pronounced than the shift away from the publisher in Germany. Furthermore, the year coefficients are jointly insignificant at the 1% significance level as $F(6, 5859) = 2.64$, $p = 0.0148$, see Table B11 in online Appendix B for details.

The differences across disciplines might be simply driven by shifts away from Elsevier towards the two DEAL publishers. If so, the effect should be the strongest for disciplines in which Elsevier holds the highest market shares prior to the cut-off. Table 7 presents them below. Except for philosophy, where the publisher does not host any single-field journals, according to SCImago, and dentistry, it has a strong market position everywhere. The

Table 9 Largest publishers by 'multidisciplinary' publications from German authors

Publisher	#Papers	Share (%)	Cum. (%)
Elsevier	9724	27.16	27.16
MDPI	4750	13.27	40.43
Wiley [DEAL]	4645	12.98	53.41
American Chemical Society*	3768	10.53	63.93
Springer Nature [DEAL]	3315	9.26	73.19
Royal Society of Chemistry*	1489	4.16	77.35
Institute of Physics*	1284	3.59	80.94
American Physical Society*	1180	3.30	84.24
American Institute of Physics*	585	1.63	85.87
Electrochemical Society*	566	1.58	87.45
Other	4,493	12.55	100
Total	35,798		

The asterisk signs publishers which have concluded transformative agreements with German consortia aside from the DEAL that are active in at least one year in 2019–2022 and cover at least 100 expected publications. Springer Nature and Wiley are exempt as they closed the DEAL. The label 'multidisciplinary' captures those observations that occur at least in two different disciplines in the dataset. Overall time window: 2016–2022

highest shares are among multidisciplinary journals (35.47%) and environmental studies (30.16%), both with null effects for the DEAL publishers. However, the positive effects I detect for material science and economics appear in fields with a strong presence of Elsevier as well. On the other hand, the publisher has a somewhat weaker position in chemistry.

The general shift away from Elsevier in Germany depicted in Figs. 2 and 4 is part of the control group in the main regressions. Thus, excluding them implies that the downward trend of this publisher is missing, which bolsters the likelihood of appearing in a journal as part of the control group. In Table 15 in Appendix 1, I present the sensitivity analysis for excluding Elsevier from the sample. One can see that the significantly positive effects for material science, chemistry, and economics disappear, and the marginal effect for the other disciplines remains statistically insignificant except for 'multidisciplinary' papers. Here, excluding publications in Elsevier journals leads to a significantly negative coefficient. While the shift away from Elsevier may have rooted researchers in the three disciplines mentioned above to journals of the two DEAL publishers, the strong movement towards other publishers of multidisciplinary papers was statistically reduced by the presence of Elsevier in the control group. Excluding this publisher led to stronger growth in the control group, which, in turn, caused the marginal effect of the DEAL in this discipline to become negative.[24]

[24] The generally negative coefficient for multidisciplinary papers might be caused by the particularly strong market position of fully open-access publishers for these kinds of publications, e.g., MDPI or Frontiers. Figure 5 in Appendix 1 shows that the full open-access publishers grew particularly strongly (relative to 2019) in Germany in the field of multidisciplinary publications compared to the rest of the world. Together with the exclusion of the negative development of Elsevier, this is likely to explain the negative coefficient of the marginal effect of the DEAL for this field.

Table 10 Publications of the DEAL publishers across fields and separated by the country affiliation of the researchers

Field	non-German publications			German publications			Δ	
	DEAL	Other	DEAL share (%)	DEAL	Other	DEAL share (%)	Abs.	Rel. (%)
Env.	85,290	241,196	26.1	2634	6001	30.5	4.4pp	16.8
Phil.	9006	32,377	21.8	597	1461	29.0	7.2pp	33.3
Phys.	64,582	377,125	14.6	2545	12,439	17.0	2.4pp	16.2
Psych.	35,513	135,549	20.8	1624	6760	19.4	− 1.4pp	− 6.7
Mat.	69,151	304,250	18.5	2288	7282	23.9	5.4pp	29.1
Chem.	149,830	650,818	18.7	11,490	23,869	32.5	13.8pp	73.6
Dent.	11,724	36,294	24.4	675	1264	34.8	10.4pp	42.6
Econ.	17,906	67,718	20.9	1578	3707	29.9	8.9pp	42.8
Mult.	79,065	363,672	17.9	3043	10,652	22.2	4.4pp	24.4
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

The DEAL column lists all publications of the two covered publishers Springer Nature and Wiley. All publications before July 1, 2019 are listed. The 'DEAL share' columns capture the share of the DEAL publications of the total publications. In particular, to compute columns (4) and (7), column (2) is divided by the sum of columns (2) and (3); column (5) is divided by the sum of columns (5) and (6), respectively. Column (8) shows the difference in DEAL shares, i.e., column (7) - column (4), in percentage points (pp), the last column (9) weights the absolute difference by the DEAL share of the non-German publications, i.e., dividing (8) by (4)

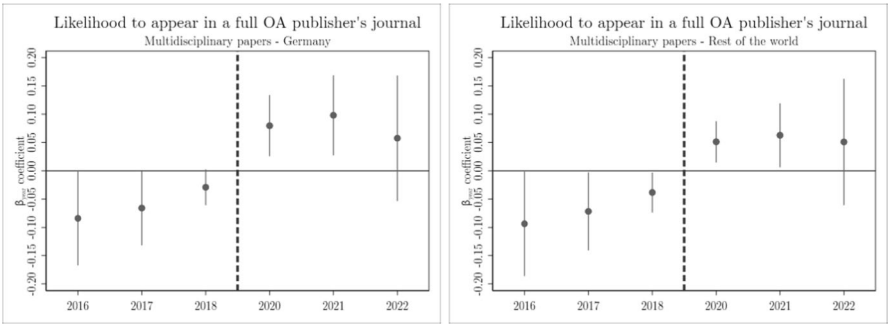

Fig. 5 Year coefficients for a paper to appear in a journal of a full open access publisher – multidisciplinary papers. Dependent variable: Binary indicator whether a *multidisciplinary* paper has been published in a journal of one of the following full open access publishing firms: eLife, Frontiers, Hindawi, MDPI, Public Library of Science. Explanatory variables: A set of dummies for each year as shown in eq. (1). Reference year: 2019. The dashed line in the plot marks this. Standard errors heteroskedasticity robust and clustered on the journal level. 95% confidence bands shown. $N_{LHS} = 35,800$, $N_{RHS} = 1,219,601$ LHS: Publications from Germany. RHS: Publications from all other countries. Exact estimates are shown in Tables B8 (LHS) and B9 (RHS) in the online appendix.

Competing transformative agreements

The DEAL agreements are, by far, the most extensive transformative agreements in Germany, simply because they are closed not only with two of the largest publishers but also because nearly all research institutions in Germany are part of the buyer consortium. Nevertheless, other contracts fall in the study's time frame as well. Besides the centralized

DEAL consortium, plenty of consortia negotiated additional transformative agreements with other publishers. They encompass fewer institutions or a smaller and sometimes fixed amount of covered publications. The 'ESAC' database lists 61 TAs beginning in the years 2019 - 2022 aside from the two DEAL agreements.[25] The four years are consciously chosen as they cover the treatment window of my difference-in-differences analysis.

As an example, I look at TAs closed with publishers specializing in physics and multidisciplinary papers, as these are the two disciplines with negative coefficients (even though wholly insignificant) and with a large sample size.[26] The Max Planck Digital Library (MPDL), an administrative branch of the Max Planck Institutes, concluded transformative agreements with the American Physical Society (APS) and the American Institute of Physics (AIP) for the years 2020–2025 and 2020– 2022 respectively. They expect to cover 350 (2020) or 380 (2021−2025) publications in APS journals and 120 (2020–2022) in AIP outlets. The TIB consortium, led by the eponymous TIB library of the Leibniz University Hannover, also negotiated a TA with AIP, which shall cover 550 publications annually from 2021 to 2023. Similarly, both organizations closed TAs with the Institute of Physics (IOP), which cover the years 2018–2024 (MPDL) and 2019–2024 (TIB). The MPDL plans to fund 140 publications per year (2018−2021) and, from 2022 on, 170 publications. The TIB agreements even encompass 400 papers in the first contract period (2019–2021) and 600 papers from 2022 to 2024. Hence, all of these agreements are non-negligible in their size. In addition, APS, AIP, and IOP are three leading discipline-specific publishers in physics.

The transformative agreements fall directly in the treatment window of the DEALs. Even though I cannot provide causal evidence, it may support hypothesis (III) holds, i.e., other publication incentives could outrival the DEAL benefits or other characteristics of the publishing market in these disciplines are more dominant than the DEAL. Tables 8 and 9 show the ten largest publishers in terms of publications from authors with a German affiliation. The asterisk behind a name marks the existence of a transformative agreement between some German institutions or a German consortium, which is different from the DEAL project and includes at least 100 annual publications. One can easily see that among the ten most important publishers in physics in Germany, five of them have at least one TA aside from the transformative DEAL agreements with Springer Nature and Wiley. For multidisciplinary publications, there are even six publishers covered.

Market shares of the DEAL publishers

While it is a strong indicator that changes are happening in the academic publishing market aside from the DEAL agreements, there seems to be no clear evidence why the point estimates for physics and multidisciplinary publications are negative and insignificant. This is because – as shown in Tables 16 and 17 in the appendix 1 – there also exist five competing transformative agreements in the disciplines of chemistry and economics in Germany, which both significantly shift towards the DEAL outlets. Hence, further reasons are likely to exist for the difference between chemistry and the many null effects of the other disciplines.

Table 10 displays the differences in the market shares of the two DEAL publishers, Springer Nature and Wiley, ahead of the beginning of the DEAL conditions across disciplines and separated by publications from authors with affiliations in Germany and the rest of the

[25] See the ESAC Transformative Agreement Registry, https://esac-initiative.org/about/transformative-agreements/agreement-registry/, last updated June 30, 2023, last checked July 13, 2023.

[26] The field of philosophy has a negative marginal effect as well, but is a rather small discipline, as Table 1 beforehand demonstrates.

world. One can see that both publishers have higher market shares in Germany than in the rest of the world in every discipline studied in this paper except for psychology.[27] However, the spread reaches its maximum for chemistry, dentistry, and economics. If one puts the difference in market shares in relation to the global market share (without Germany), one can see that Wiley and Springer's market share in Germany in chemistry is 73.6% higher compared to the rest of the world, as column (9) highlights. For economics, the difference counts for 42.8%, and for dentistry, it is 42.6%. Hence, the two disciplines that face a significant shift towards DEAL are already heavily relying on both publishers in Germany. In addition, the combined market share of Wiley and Springer Nature in Germany is the lowest for physics and the third lowest for multidisciplinary papers, considering all disciplines studied in this paper.[28]

Even though still suggestive, it is implicative evidence that the DEAL might be more substantial in those disciplines, in which Springer Nature and Wiley already possess a strong market position. Vice versa, for papers in physics and those assigned to multiple disciplines, Wiley and Springer Nature tend to have a less attractive portfolio ahead of the introduction of the DEAL agreements. It corresponds to the well-known 'Matthew effect' in science (Merton, 1968), which states that successful researchers become even more successful by receiving high credit for collaborative work. The 'Matthew effect' in the present case relates to publishers. If they already possess a strong market position, transformative agreements may further bolster their market shares. But if in a weaker position, transformative agreements might not have the same effect.

Conclusion and outlook

How transformative are transformative agreements? After looking at the results of this paper, the question can be altered to: Are transformative agreements transformative regarding publication preferences of researchers? By design, the DEAL fosters open access, including it for every publication in an eligible journal by default. Regarding competition in the publishing market, the evidence from Germany can offer only an opaque picture. Analyzing the impact of the two German transformative agreements with Springer Nature and Wiley on eight disciplines (and a residual multidisciplinary field) and 6.1 million publications raises one central issue: Either the actual (theoretically positive) effect is not quite visible in the econometric estimation, or the DEAL contracts do not change the publishing market in the sense that they cause overwhelming interest among academics to publish their work in eligible journals (at least in the short run). My data ends in December 2022, covering three years of treatment in the case of Springer Nature and even 3.5 years in the case of Wiley. So, even if such treatments require much time to unfold completely, the average turnaround time of a paper is shorter than the treatment window. However, it takes time until such policy changes become widely known among academics. Hence, even such a treatment window can only offer early evidence.

[27] This is reasonable in light of the strong position of Springer Nature in Germany due to the fact that Springer has its roots in Germany, where it was founded in 1842 and became one of the most important academic publishers in the first half of the 20th century, see https://www.springer.com/gp/about-springer/history, last checked August 14, 2023.

[28] As mentioned, dentistry and, in addition, philosophy are two disciplines with null effects but a particularly strong position of the two DEAL publishers. Here, the comparatively low number of observations is likely to cause the estimated null results. Especially for dentistry, the confidence intervals are quite large as one could see in Fig. 1 beforehand.

Plenty of null effects offset the positive effects observed in chemistry, economics, and materials science. They suggest that the multitudinous parallel upheavals in the academic publishing market are likely to play a role and are highly discipline-specific, particularly in Germany, where the cut-off from Elsevier has been an additional factor. The suggestive evidence that the effects are the strongest in those disciplines where the two treated publishers have had a dominant position ex-ante is not helpful for competition in these fields. In contrast, it does not (yet) seem to change the publishing landscape in disciplines where the two DEAL publishers do not possess such a vital role. If true and persistent over time, it does not support the concerns raised by Haucap et al. (2021) that the DEAL will foster concentration in the academic publishing market *per se*.

Looking at policy implications, the heterogeneous findings and the entangled environment raise the yet-to-be-answered question of how one can evaluate such interventions properly. Due to the high amount of money involved, this is a nontrivial task. Not only is a discipline-specific evaluation necessary, but my findings also raise the question of how the leading publishers react to potentially continuing declines in submissions as they are the only source of income under transformative agreements.

Appendix

See Tables (11, 12, 13, 14, 15, 16, 17, 18)

Table 11 Publications by year

Year	#publications	Share (%)	Cumulative (%)
2016	725,057	11.84	11.84
2017	757,120	12.36	24.20
2018	819,885	13.38	37.58
2019	892,285	14.57	52.15
2020	953,805	15.57	67.72
2021	930,715	15.19	82.91
2022	1,046,820	17.09	100
Total	6,125,687	100	

Table 12 Publications by discipline and the share of German corresponding authors

Discipline	#Non German	#German	German share (%)	Total
Env. Studies	841,110	20,933	2.43	862,043
Philosophy	94,227	4491	4.55	98,718
Physics	887,832	29,251	3.19	917,083
Psychology	389,408	18,914	4.63	408,322
Material Science	766,921	18,143	2.31	785,064
Chemistry	1,432,437	60,711	4.07	1,493,148
Dentistry	103,426	3709	3.46	107,135
Economics	187,670	11,103	5.59	198,773
Multidisciplinary	1,219,601	35,800	2.85	1,255,401
Total	5,922,632	203,055	3.31	6,125,687

Table 13 Number of publications by SJR quartile—raw data

Quartile	#publications	Share (%)	Cumulative (%)
SJR quartile 1	1,325,710	21.64	21.64
SJR quartile 2	1,546,492	25.25	46.89
SJR quartile 3	1,605,302	26.21	73.09
SJR quartile 4	1,648,183	26.91	100.00
Total	6,125,687	100	

The SJR criterion increases in impact. Quartile 1 embodies publications from journals with the lowest impact and quartile 4 those from journals with the highest impact. Numbers for the raw SJR quartiles computed before removing duplicates and publications without an SJR value

Table 14 Fraction of treated observations by discipline

Field	Not treated	Treated	Total
Env. Studies	849,745	12,298	862,043
Philosophy	96,285	2433	98,718
Physics	902,816	14,267	917,083
Psychology	397,792	10,530	408,322
Material Sc.	776,491	8573	785,064
Chemistry	1,467,796	25,352	1,493,148
Dentistry	105,365	1770	107,135
Economics	192,955	5818	198,773
Multidiscipl.	1,233,296	22,105	1,255,401
Total	6,022,541	103,146	6,125,687

Column 2—'not treated'—aggregates all control group observations as well as treatment group observations ahead of the treatment

Table 15 Marginal effects separated by discipline excluding publications in Elsevier journals

	AME	Std.Err.	t-stat.	p-value	95% CI		*N*
Env. Studies	− 0.0157	0.0203	− 0.77	0.441	− 0.0555	0.0242	599,316
Philosophy	− 0.0124	0.0188	− 0.66	0.509	− 0.0493	0.0245	98,718
Physics	− 0.0176	0.0148	− 1.19	0.236	− 0.0468	0.0116	774,018
Psychology	0.0095	0.0210	0.46	0.649	− 0.0316	0.0507	337,165
Material Sc.	0.0320	0.0210	1.52	0.128	− 0.0092	0.0733	550,180
Chemistry	0.0289	0.0199	1.45	0.146	− 0.0101	0.0680	1,125,873
Dentistry	0.0332	0.0491	0.68	0.500	− 0.0637	0.1301	95,423
Economics	0.0394	0.0256	1.54	0.124	− 0.0108	0.0896	150,026
Multidiscipl.	− 0.0454**	0.0219	− 2.08	0.038	− 0.0884	− 0.0025	813,372

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors heteroskedasticity-robust and clustered on the journal level. Observations for each regression reported in the last column on the right

Table 16 Largest publishers by publications from German authors in chemistry

Publisher	#Papers	Share (%)	Cum. (%)
Wiley [DEAL]	15,811	26.04	26.04
American Chemical Society*	11,479	18.91	44.95
Elsevier	9604	15.82	60.77
Royal Society of Chemistry*	6668	10.98	71.75
MDPI	5874	9.68	81.43
Springer Nature [DEAL]	4831	7.96	89.39
American Institute of Physics*	1085	1.79	91.17
de Gruyter*	814	1.34	92.52
Taylor & Francis*	634	1.04	93.56
Thieme	556	0.92	94.48
Other	3351	5.52	100
Total	60,710		

The asterisk signs publishers which have concluded transformative agreements with German consortia aside from the DEAL that are active in at least one year in 2019–2022 and cover at least 100 expected publications. Springer and Wiley are exempt as they closed the DEAL. Overall time window: 2016–2022

Table 17 Largest publishers by publications from German authors in economics

Publisher	#Papers	Share (%)	Cum. (%)
Elsevier	2731	26.45	26.45
Springer Nature [DEAL]	2236	21.65	48.10
Wiley [DEAL]	1236	11.97	60.07
Routledge	516	5.00	65.06
de Gruyter*	471	4.56	69.62
Taylor-Francis*	403	3.90	73.53
Oxford University Press*	163	1.58	76.61
Emerald Group Publishing	243	2.34	78.95
Academic Press	237	2.29	81.24
Cambridge University Press*	163	1.58	82.82
Other	1774	17.18	100
Total	10,327		

The asterisk signs publishers which have closed transformative agreements with German consortia aside from the DEAL that are active in at least one year in 2019–2022 and cover at least 100 expected publications. Springer and Wiley are exempt as they closed the DEAL. Overall time window: 2016–2022

Table 18 List of DEAL journals with the highest change (since 2018) in the share of corresponding authors from German institutions

Journal Title	Change	Field	Publisher
Tijdschrift Voor Economische en Sociale Geografie (Journal of Economic and Human Geography)	0.2667	**Economics**	Wiley
Palaeobiodiversity and Palaeoenvironments	0.2297	Env. Studies	Springer Nature
PFG-Journal of Photogrammetry, Remote Sensing and Geoinformation Science	0.2185	Physics	Springer Nature
WMU Journal of Maritime Affairs	0.2015	Env. Studies	Springer Nature
Current Protocols in Nucleic Acid Chemistry	0.1822	**Chemistry**	Wiley
GENEVA Risk and Insurance Review	0.1818	**Economics**	Springer Nature
Journal of Biomolecular NMR	0.1792	**Chemistry**	Springer Nature
Journal of Neuropsychology	0.1724	Psychology	Wiley
Journal of Polymer Science, Part A: Polymer Chemistry	0.1677	**Chemistry**	Wiley
ChemistryOpen	0.1672	**Chemistry**	Wiley
International Economics and Economic Policy	0.1649	**Economics**	Springer Nature
Philosophy and Technology	0.1546	Philosophy	Springer Nature
European Journal for Philosophy of Science	0.1500	Philosophy	Springer Nature
Natural Resource Modelling	0.1461	Env. Studies	Wiley
IMF Economic Review	0.1351	**Economics**	Springer Nature
Engineering in Life Sciences	0.1337	Env. Studies	Wiley
Journal of Philosophy of Education	0.1208	Philosophy	Wiley (OUP since 2023)
Ethik in der Medizin	0.1197	Philosophy	Springer Nature
Spectroscopy Europe	0.1183	**Chemistry**	Wiley
Progress in Photovoltaics: Research and Applications	0.1181	**Multidisc.***	Wiley

The asterisk marks the 'multidisciplinary' of 'Progress in Photovoltaics: Research and Applications,' because even though the category 'multidiscilpinary' is not significantly affected by the DEAL, its journals are assigned to several other categories, in this case, the journal is assigned to Material Sciences and Physics. The former is significantly affected. The change is computed as the cumulative annual nominal change in market shares relative to 2018, the year before the Wiley DEAL was established. Thus, 'change' uses the changes from 2022 to 2021, 2021 to 2020, 2020 to 2019, and 2019 to 2018 and adds them up. The table shows the 20 journals with the highest values for this type of change

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11192-024-04955-y.

Acknowledgements This project benefited from fruitful discussions with Ulrich Herb. I am thankful for very helpful feedback from the editor, Lin Zhang, the anonymous referees, as well as from Oliver Budzinski, Justus Haucap, and Leon Knoke. Financial support from the German Research Foundation (Funding No. #235577387/GRK 1974) is gratefully acknowledged.

Funding Open Access funding enabled and organized by Projekt DEAL.

References

Abramo, Giovanni, D'Angelo, Ciriaco Andrea, & Mele, Ida. (2022). Impact of Covid-19 on research output by gender across countries. *Scientometrics, 127*(12), 6811–6826.

Borrego, Ángel., Anglada, Lluís, & Abadal, Ernest. (2021). Transformative agreements: Do they pave the way to open access? *Learned Publishing, 34*(2), 216–232.

Costas, Rodrigo, & Bordons, María. (2011). Do age and professional rank influence the order of authorship in scientific publications? Some evidence from a microlevel perspective. *Scientometrics, 88*(1), 145–161.

Eisen, Michael B., et al. (2022). Peer review without gatekeeping. *eLife, 11*, e83889.

Engers, Maxim, Gans, Joshua S., Grant, Simon, & King, Stephen P. (1999). First- Author Conditions. *Journal of Political Economy, 107*(4), 859–883.

Fischer, Kai, Reade, J. James., & Schmal, W. Benedikt. (2022). What cannot be cured must be endured: The long-lasting effect of a COVID-19 infection on workplace productivity. *Labour Economics, 79*, 102281.

Fourcade, Marion, Ollion, Etienne, & Algan, Yann. (2015). The superiority of economists. *Journal of Economic Perspectives, 29*(1), 89–114.

Fraser, Nicholas, et al. (2023). No deal: German researchers' publishing and citing behaviors after Big Deal negotiations with Elsevier. *Quantitative Science Studies, 4*(2), 325–352.

Gao, Jian, et al. (2021). Potentially long-lasting effects of the pandemic on scientists. *Nature Communications, 12*(1), 6188.

Hadavand, Aboozar, Hamermesh, Daniel S., & Wilson, Wesley W. (forthcoming). "Publishing Economics: How Slow? Why Slow? Is Slow Productive? How to Fix Slow?" In: *Journal of Economic Literature. forthcoming*

Haucap, Justus, Moshgbar, Nima, & Schmal, W. Benedikt. (2021). The impact of the German 'DEAL' on competition in the academic publishing market. *Managerial and Decision Economics, 42*(8), 2027–2049.

Heckman, James J., & Moktan, Sidharth. (2020). Publishing and promotion in economics: The tyranny of the top five. *Journal of Economic Literature, 58*(2), 419–470.

Hinchliffe, Lisa Janicke. (2019). Read-and-publish? Publish-and-read? A primer on transformative agreements. *Published April 23, 2019, last checked June 26, 2023*

Lapidow, Amy, & Scudder, Paige. (2019). Shared first authorship. *Journal of the Medical Library Association : JMLA, 107*(4), 618–620.

McCabe, Mark J., & Snyder, Christopher M. (2005). Open access and academic journal quality. *American Economic Review, 95*(2), 453–458.

Merton, Robert K. (1968). The matthew effect in science. *Science, 159*(3810), 56–63.

Mingers, John, & Yang, Liying. (2017). Evaluating journal quality: A review of journal citation indicators and ranking in business and management. *European Journal of Operational Research, 257*(1), 323–337.

Moskovkin, Vladimir M., Saprykina, Tatyana V., & Boichuk, Igor V. (2022). Transformative agreements in the development of open access. *Journal of Electronic Resources Librarianship, 34*(3), 165–207.

Rose, Michael E., & Kitchin, John R. (2019). pybliometrics: Scriptable bibliometrics using a Python interface to Scopus. *SoftwareX, 10*, 100263.

Schmal, W. Benedikt. (2023a). "The 'Must Stock' Challenge in Academic Publishing: Pricing Implications of Transformative Agreements". *mimeo*

Schmal, W. Benedikt. (2023b). "The X Factor: Open Access, New Journals, and Incumbent Competitors". In: *MSI Discussion Paper No. 2307. KU Leuven*

Schmal, W. Benedikt. (2023c). "Vice Versa: The Decoupling of Content and Topic Heterogeneity in Collusion Research". In: *Journal of Economic Surevys. forthcoming*

Schmal, W. Benedikt, Haucap, Justus., & Knoke, Leon. (2023). "The role of gender and coauthors in academic publication behavior". In: *Research Policy 52.10*

Suber, Peter. (2012). **Open Access**. Cambridge, MA: MIT Press.

Waltman, Ludo. (2012). An empirical analysis of the use of alphabetical authorship in scientific publishing. *Journal of Informetrics, 6*(4), 700–711.