



Understanding differences of the OA uptake within the German university landscape (2010–2020): part 1—journal-based OA

Niels Taubert¹ · Anne Hobert² · Najko Jahn² · Andre Bruns¹ · Elham Irvani¹

Received: 22 September 2022 / Accepted: 19 April 2023
© The Author(s) 2023

Abstract

This study investigates the determinants for the uptake of Full and Hybrid Open Access (OA) in the university landscape of Germany and distinguishes between three factors: The disciplinary profile, infrastructures and services of universities that aim to support OA, and large transformative agreements. The uptake of OA, the influence of the disciplinary profile of universities and the influence of transformative agreements is measured by combining several data sources (incl. Web of Science, Unpaywall, an authority file of standardised German affiliation information, the ISSN-Gold-OA 4.0 list, and lists of publications covered by transformative agreements). For infrastructures and services that support OA, a structured data collection was created by harvesting different sources of information and by manual online search. To determine the explanatory power of the different factors, a series of regression analyses was performed for different periods and for both Full as well as Hybrid OA. As a result of the regression analyses, the most determining factor for the explanation of differences in the uptake of both OA-types turned out to be the disciplinary profile. For the year 2020, Hybrid OA transformative agreements have become a second relevant factor. However, all variables that reflect local infrastructural support and services for OA turned out to be non-significant. To deepen the understanding of the adoption of OA on the level of institutions, the outcomes of the regression analyses are contextualised by an interview study conducted with 20 OA officers of German universities.

Keywords Open access · Journal-based open access · Hybrid open access · Gold open access scholarly communication · Empirical study · German university landscape · Transformative agreements · Regression analysis

✉ Niels Taubert
niels.taubert@uni-bielefeld.de

¹ Institute for Interdisciplinary Studies of Science (I2SoS), Bielefeld University, Bielefeld, Germany

² Göttingen State and University Library, University of Göttingen, Göttingen, Germany

Introduction

The uptake of Open Access (OA) on the level of institutions has increased in relevance for a number of reasons. Recent science policies and OA strategies have announced that certain percentages of the publication output should be OA at a defined point in time, and universities and other research institutes are committed to such targets. Moreover, funding programmes have been developed that aim to build up infrastructures for the support of OA at remarkable scale, and such programmes are subject to evaluation. One evaluation criterion is, of course, the development of OA in the publication output of participating institutions.¹ Finally, a number of organisations have implemented monitoring and research information systems that aim to measure OA shares on the level of institutions and are supposed to provide information for the further OA transition.² On a larger scale, a number of research studies has addressed the question about the dynamics of the uptake of OA. With some exceptions, there is evidence that OA is growing (Archambault et al., 2014; Laakso & Björk, 2012; Piwowar et al., 2018; Pölönen et al., 2020; Severin et al., 2020) with striking differences across institutions (Bosman & Kramer, 2018; Huang et al., 2020; Wohlge-muth et al., 2017) and countries (Robinson-Garcia et al., 2020). In addition, the distinction of different OA types in these studies shows that the uptake of OA is a multidimensional phenomenon (Hobert et al., 2021; Piwowar et al., 2018).

To date, the causes for differences in the uptake of OA are primarily studied on the level of individuals (Boselli & Galindo-Ruedai, 2016; Tenopir et al., 2017; Rowley et al., 2017; Greussinger et al., 2020), disciplines³ and countries (Momeni et al., 2022), but rarely on the level of institutions (Greussinger et al., 2020). For institutions, it seems plausible at first glance that different types of factors may play a role. First, there is some evidence that research institutions do not show an equal level of activities when it comes to the support of OA. This does not only hold for services but also for the availability and maintenance of OA infrastructures. Second, the relevant environment, like, for example, guidelines or prescriptions of research policy or guidelines of relevant funding organisations, may be more or less OA-friendly and may result in differences to what extent the publication output of a research organisation is OA. Finally, a number of studies report large differences regarding the OA share in different disciplines and fields.⁴ Regarding institutions, the hypothesis seems plausible that differences of the uptake of OA may simply be a reflection of the OA affinity of the disciplinary profile of a research institution. To put it in different words, the question is unanswered whether it is the composition of scientific disciplines, the organisational environment or the inner-organisational support of OA publishing that explains the differences in the uptake.

¹ Ploder et al., 2020.

² Examples are for the EU the Open Science Monitor (https://research-and-innovation.ec.europa.eu/strategy/strategy-2020-2024/our-digital-future/open-science/open-science-monitor/trends-open-access-publications_en), for Germany the OA Monitor for Germany (Barbers et al., 2022 and <https://open-access-monitor.de/>), for UK monitoring activities of the universities (<https://www.universitiesuk.ac.uk/what-we-do/policy-and-research/publications/monitoring-transition-open-access>), for Denmark the Danish OA Indicator (<https://www.oaindikator.dk/en/>), for France the French Open Science Monitor (<https://frenchopensciencemonitor.esr.gouv.fr/>) and for Australia the COKI Open Access Dashboard (<http://openknowledge.commu-nity/dashboards/coki-open-access-dashboard/>), all accessed March 23th 2023).

³ See Severin et al., 2020 for an overview.

⁴ See Martin-Martin et al. (2018) for an overview; Piwowar et al., 2018; Science-Metrix, 2018; Björk & Korkeamäki (2020).

To date, individual factors like, for example, OA mandates (Gargouri et al., 2012; Lari-vière & Sugimoto, 2018; Kirkmann & Haddow, 2020) or publication funds (Ploder et al., 2020) have been studied to determine their influence on the OA share of institutions. To the best of our knowledge, our study is the first one that addresses the question of how multiple determinants account for the uptake of OA on the level of institutions with a focus on the German university landscape. The case is well suited for such an exploration for several reasons: German universities have a strong publication output and the landscape is diverse (Agasisti & Pohl, 2012). The 121 German universities do not only differ regarding their size but also with respect to the composition of their disciplinary profile. In addition, the advancement of OA has been supported as a priority of funding organisations as well as various institutions. Last but not least, the nationwide consortium DEAL was created, under which two OA transformative agreements were negotiated (Haucap et al., 2021). To sum up, the case of German universities allows us to study the effects of different mechanisms for the advancement of OA in a diverse university landscape.

The article is organised as follows: In a first step, three types of determinants are introduced that may influence the OA uptake at German universities (Section “Possible determinants and hypotheses”), and corresponding hypotheses are developed. The methods of the analysis are described in Section “Data and methods”. In Section “Results”, descriptive statistics are given and the results of the regression models for the determinants of the adoption of OA are presented. In the discussion section (Section “Discussion”), the findings of the quantitative study are complemented with insights of an interview study with OA representatives of German universities that give some context and background information about the factors investigated. In addition, the limitations of the study are discussed. The conclusion (Section “Discussion”) summarises the most important results.

Possible determinants and hypotheses

This study focuses on OA provided by journals (‘gold OA’, Suber, 2012) in the publication output of German universities. It further differentiates between Full OA and Hybrid OA and asks the question to what extent possible determinants affect the OA share of the German university landscape.⁵

Disciplinary profile

A first factor that may have an influence on the journal-based OA share of universities is their disciplinary profile. A number of studies have shown that disciplines differ regarding their affinity towards OA and their preferences of a particular OA type (Zhu, 2017; Science-Metrix, 2018; Piwowar et al., 2018; Dalton et al., 2020; Severin et al., 2020; Robinson-Garcia et al., 2020; Björk & Korkeamaki, 2020). Therefore, the composition of the disciplinary profile with a corresponding affinity towards OA may affect the OA-share of universities.

⁵ It is complemented by a second article that focuses on Suber’s (2012) other major OA-type, i.e. OA provided by repositories (‘green OA’).

Universities' OA infrastructures and services

A second type of factor comprises all efforts that universities have undertaken to support OA. Up to now, such efforts are many. They include digital infrastructures, OA services, and staff. Additional instruments are OA policies that universities apply to express their support for OA. Services comprise the provision of information and training or practical support, like, for example, the assistance for self-archiving. OA infrastructures include repositories for depositing (and aggregating) research, publishing platforms like Open Journal Systems (OJS) that are used for the hosting of OA journals, and publication funds for financing article processing charges (APC) or book processing charges (BPC). Given that universities differ regarding their efforts to support OA, one can assume that it may impact the OA share of the institutions.

Transformative agreements

In recent years (Schimmer et al., 2015) transformative agreements have become a prominent and controversially discussed instrument to make research OA. Transformative agreements are usually orchestrated negotiations between a number of institutions and a publisher that aims to transform the business model for part of their journals or the complete portfolio into a full OA model. During the transition period, institutions pay a fee that covers both costs for accessing the content of the journals and publication fees for turning publications in such journals into OA. For Germany, the most impactful contracts are those that were negotiated by large publishing houses and project DEAL.⁶ To date, they operate on an 'all-in-principle' of nearly all public research institutions, the contracts can be regarded as a central coordination mechanism that affects the entire German research system. Given that the share of publications covered by such contracts varies from university to university, we assume that transformative agreements may affect their individual OA share.

Now that the three factors are introduced, two journal-based OA types are distinguished:

- *Full OA (F)*: Full OA means articles published in journals in which all content is immediately freely available online without charging any fees for accessing it.
- *Hybrid OA (H)*: In the case of Hybrid OA, individual articles are made openly available under an open licence usually by paying a fee, while the journal as a whole remains subscription-access (Jahn et al., 2022).

Full OA and Hybrid OA follow independent logics. Therefore, the hypotheses are formulated individually for each type:

Full OA

F-1 Hypothesis on infrastructural requirements (part of universities' infrastructures and services).

⁶ <https://www.projekt-deal.de/about-deal/> (accessed March 23th 2023).

H₁ Universities with a publication fund have a larger Full OA share than universities without a publication fund.

H₀ Universities with a publication fund have a smaller (or equal) OA share than universities without a publication fund.

F-2 Hypothesis on the impact of OA policies, OA officers, OA information and OA events (part of universities' infrastructures and services)

H₁ There is a need for educating researchers regarding the advantages of the APC-liable Full OA model. Universities that are highly engaged in educating and encouraging scientists (provision of OA information and organisation of OA events, supported by OA officers and OA policies) have a higher Full OA share than universities that are less engaged.

H₀ Universities that are highly engaged in educating and encouraging scientists (provision of OA information and organisation of OA events, supported by OA officers and OA policies) have a smaller (or equal) Full OA share than universities that are less engaged.

F-3 Hypothesis on the influence of the disciplinary profile

H₁ Universities with a disciplinary profile that shows a strong affinity towards Full OA have a larger Full OA share than universities with a weaker affinity towards Full OA.

H₀ Universities with a disciplinary profile that shows a strong affinity towards Full OA have a smaller (or equal) Full OA share than universities with a weaker affinity towards Full OA.

F-4 Hypothesis on the influence of transformative agreements

H₁ The larger the share of Full OA articles covered by DEAL, the larger is the overall Full OA share of a university.

H₀ The larger the share of Full OA articles covered by DEAL, the smaller is the overall Full OA share of a university.

Hybrid OA

H-1 Hypothesis on infrastructural requirements (part of universities' infrastructures and services)

H₁ Universities with a publication fund have a higher Hybrid OA share than universities without a publication fund.

H₀ Universities with a publication fund have a smaller (or equal) Hybrid OA share than universities without a publication fund.

H-2 Hypothesis on the impact of OA policies, OA officers, OA information and OA-events (part of universities' infrastructures and services)

H₁ There is a need for educating scientists regarding the advantages of the APC-liable Hybrid OA model. The stronger a university is engaged in educating and encouraging scientists (provision of OA information and organisation of OA events, supported by OA officers and OA policies) the larger is the Hybrid OA share.

H₀ The stronger a university is engaged in educating scientists in OA (provision of OA information and organisation of OA events, supported by OA officers) the smaller is the Hybrid OA share.

H-3 Hypothesis on the influence of the disciplinary profile

H₁ Universities with a disciplinary profile that shows an affinity towards Hybrid OA have a larger Hybrid OA share than universities with a disciplinary profile with less affinity towards Hybrid OA.

H₀ Universities with a disciplinary profile that shows an affinity towards Hybrid OA have a smaller (or equal) Hybrid OA share than universities with a disciplinary profile with less affinity towards Hybrid OA.

H-4 Hypothesis on the influence of transformative agreements

H₁ The larger the share of Hybrid OA articles covered by DEAL, the larger is the overall Hybrid OA share of a university.

H₀ The larger the share of Hybrid OA articles covered by DEAL, the smaller is the overall Hybrid OA share of a university.

Data and methods

The study combines three types of data: Bibliometric data of the publication output complemented with OA evidence, structural data and information about OA infrastructures, and interviews with OA officers and OA representatives from German universities.

The *publication output* of German universities was identified through the Web of Science in-house database maintained by the German Competence Center for Bibliometrics (WoS-KB) in its 2021 version. The main advantage of using this data source in the context of our study is that it provides disambiguated address information (Rimmert et al., 2017), which allows obtaining the publication output represented in the Web of Science on the level of institutions with a “near-complete national-scale coverage” of Germany’s institutions at a high accuracy (Donner et al., 2020). Publishing articles as Hybrid OA usually involves the obligation to pay APCs, and the same is true for the majority of articles published in Full OA journals as well (Smith et al., 2021). Given this and the fact that the existence of funding mechanisms (like publication funds or transformative agreements) may play a role in the uptake of OA, the analysis was restricted to corresponding author publications. All publications of the period 2010–2020 with a corresponding author from a German university were considered. To identify articles in full OA journals, the ISSN-GOLD-OA 4.0 list (Bruns et al., 2020) and Unpaywall’s Full OA journal list were used (Piwowar et al., 2019). The Hybrid OA information was generated as follows: Based on article-level

evidence from Unpaywall, articles were assigned to the category Hybrid OA if they were classified as Hybrid OA by Unpaywall and the corresponding journal was not included in the ISSN-GOLD-OA 4.0 list (Bruns et al., 2020). Since preparation of our earlier study investigating OA shares of German research institutions (Hobert et al., 2021), Unpaywall’s classification of Hybrid OA has strongly improved (Piwowar et al., 2019). Therefore, we use the distinguished Hybrid OA category instead of our own previous ‘other_oa_journal’ category, which aside from Hybrid OA included other journal-based OA in not full OA journals (like Moving Wall OA or openly available articles on the publisher’s webpage without any open licence).

The *disciplinary profile* was conceptualised by one factor on a high level of aggregation. For each of the 255 WoS subject categories, a subject and OA category-specific share was calculated based on all publications with a corresponding author from a German institution. Publications with more than one corresponding author or with no corresponding author information available were excluded from the analysis. Based on the subject category OA shares and the number of publications in each subject category, a disciplinary influence factor was calculated for all universities and for both Full OA (X_i^F) and Hybrid OA (X_i^H), namely.

$$X_i^F(i) = \frac{1}{T_i} \sum_{s \in S} (N_{i,s} * P_s^F), \text{ and } X_i^H(i) = \frac{1}{T_i} \sum_{s \in S} (N_{i,s} * P_s^H).$$

where $X_i^F(i)$ Full OA disciplinary influence factor for university $i \in I$ the set of all included universities, $X_i^H(i)$ Hybrid OA disciplinary influence factor for university $i \in I$, $N_{i,s}$ Number of publications of university $i \in I$ in WoS subject category $s \in S$ the set of all WoS subject categories, T_i Total number of publications of university $i \in I$, P_s^F Full OA share of WoS subject category $s \in S$ (publications with German corresponding authors), and, P_s^H Hybrid OA share of WoS subject category $s \in S$ (publications with German corresponding authors).

For *universities’ OA infrastructures and services*, a structured data collection was created⁷ by harvesting different sources of information and by manual online search. The data set includes information about the size of universities (in terms of students, staff, professors, budget, and third-party funds⁸) as well as OA infrastructures and services that are provided on the local level. The last-mentioned data include information about the existence of publication funds,⁹ OA policies,¹⁰ OA officers,¹¹ OA websites and OA activities like information events or workshops announced on the universities’ websites.¹² Data collection took place between August and October 2021. The data are modelled as response variables X_2 – X_8 .

For the German university landscape, a number of transformative agreements are in place. However, data is only available for the most important contracts, namely the transformative agreements negotiated between project DEAL and the large publishing houses Wiley and SpringerNature. Although these contracts operate on an all-in principle and

⁷ The data collection with a detailed documentation published for re-use (Bruns et al., 2022).

⁸ Source: GEPRIS database (DFG, <https://gepris.dfg.de/gepris/OCTOPUS>, accessed March 22th, 2023).

⁹ Source: OpenAPC (<https://github.com/OpenAPC/openapc-de>, accessed August 29th, 2022) and manual web search.

¹⁰ Source: ROARmap (<https://roarmap.eprints.org/>, accessed March 22th, 2023).

¹¹ Sources: Bundesländeratlas Open Access (Kindling et al., 2022) and manual web search.

¹² Source: Manual web search.

include all German universities, the number of publications covered by the two DEAL contracts vary from university to university as their publication output in journals covered by the contracts differ. For our analysis of a possible influence of the DEAL contracts, the publication year 2020 is considered as this is the only year for which the transformative agreements with SpringerNature and Wiley both have been effective for the whole year and for which data are available.¹³ For each university and for each response variable (Full and Hybrid OA shares) we calculated the share of the publication output covered by DEAL contracts as

$$X_9^F(i) = \frac{DF_{(i)}}{TP_{(i)}}; \text{ and } X_9^H(i) = \frac{DO_{(i)}}{TP_{(i)}}$$

where $X_9^F(i)$ Share of Full OA publications covered by DEAL contracts for university $i \in I$, the set of all included universities, $X_9^H(i)$ Share of Hybrid OA publications covered by DEAL contracts for university $i \in I$, D_i^F Number of Full OA publications covered by DEAL contracts for university $i \in I$, D_i^H Number of Hybrid OA publications covered by DEAL contracts for university $i \in I$, and, T_i Total number of publications of university $i \in I$.

Table 1 gives an overview of the explanatory and response variables that are considered in the regression models together with their labels.

In order to put our statistical model into a broader context and to gain more detailed insights into how the different factors influence the OA shares of German universities, guided interviews were conducted with OA officers and OA representatives from 20 universities. The questions of the interview guideline addressed the local relevance of all factors that are considered in the regression model. In detail, questions referred to the perception of the support of OA by scientists and university leadership, the disciplinary profile of the university, the origination and use of OA infrastructures like repositories, publication funds, the perception of the effects of transformative agreements and OA policies as well as the reception of OA information training activities by scientists. Moreover, in preparation for the interviews, an OA profile of the particular university was created, including the overall OA share as well as the Full OA and Hybrid OA share. The numbers were presented during the interviews and discussed with the OA officers to gain a deeper understanding about the adaption of OA at the institution.

The sample of the interviewees aims to represent a large diversity of perspectives and follows the selection scheme of maximum variation (Collins et al., 2006, 84). In the case of this study, maximum variation refers to universities and includes the following dimensions: size of the university, strong and weak adaption of OA as well as the disciplinary profile. With respect to the three dimensions, the sample includes interviewees from large and small universities, universities with strong or weaker OA shares as well as universities with and without a medical faculty, technical universities and universities with a broad disciplinary mixture. The interviews were conducted between February and June 2021, and their duration varied between 47 and 119 min. For the analysis, all interviews were completely transcribed by a transcription service to guarantee maximum quality. In the course of the content analysis (Mayring, 2015) of the interviews, MAXQDA 2018 data analysis software was used, and a code tree was developed that consists of 166 codes with 3118 coded paragraphs assigned to them.

¹³ Source: DEAL operations (<https://deal-operations.de/aktuelles/publikationen-in-2020>, accessed March 22th, 2023).

Results

Descriptive statistics

In a first step, descriptive statistics are reported for categorical and metrical explanatory and response variables. However, the availability of data differs. Structural information about the German university landscape and about OA infrastructures were collected at a specific point in time when the manual research took place. In contrast, publication-based information like publication output, OA shares, and disciplinary influence scores can be calculated from data spanning different periods. Finally, information about publications covered by DEAL contracts is available for the publication year 2020. With the exception of DEAL-shares, publication-based indicators are given for three periods (2010–2020, 2017–2018, and 2020) for which regression models are calculated. The rationale for the selection of the three periods is to analyse and compare the influence of the three types of factors for the whole 11-year period, with the most recent period before the introduction of the DEAL contracts (2017–2018) and the period for which information about the DEAL contracts are available (2020).

Table 2 gives an overview of the descriptive statistics for categorical independent variables and illustrates that German universities differ regarding the mechanisms and activities they have implemented to support OA. While more than 80% of the universities have a website with OA information, nearly three quarter have an OA officer, 70% a publication fund and nearly two thirds an OA policy. Only half of the universities provide OA rights information and a bit more than a third of them information about OA courses and training on their websites.

Descriptive statistics for the duration of the adoption of OA policies at German universities are given in Table 3. The first line includes both universities with as well as without OA policies. For universities without OA policy, the duration of policy adoption was defined as 0 months. The statistics in the second line are limited to universities with OA policies.

The publication-based descriptive statistics are presented in Table 4. The table includes descriptive statistics for the total number of publications, Full and Hybrid OA share as well as the Full and Hybrid OA disciplinary influence factors for all periods. For the publication year 2020, DEAL influence factors were calculated both for Full and Hybrid OA. In a first step, all indicators were calculated for each university that overrun the threshold value of a publication output of 50 corresponding author publications for the particular period. The threshold value was introduced to exclude distortions of the OA shares and disciplinary influence factors due to small publication output. In a second step, mean value and standard deviation were calculated and minimum and maximum values were given for the German university landscape. The results in the table show that all OA shares have increased for more recent years. Particularly noteworthy is the rise of the Hybrid OA share between the period 2017–2018 and 2020 from 4.6% to 21.8% with a maximum of 30.7% for one university.

Regression models

Multiple linear regression analysis is an important statistical tool to test assumptions about structures and relations in data (Freedman, 2009). In regression analysis, the output

Table 1 Explanatory and response variables

Variable description	Label
Estimated Full OA share / Hybrid OA share based on the composition of subjects	X_1^F/X_1^H
Existence of an OA publication fund	X_2
Existence of an OA officer	X_3
Existence of a webpage with OA information	X_4
Existence of a webpage with information about OA activities	X_5
Existence of a webpage with OA rights information	X_6
Existence of an OA policy	X_7
Month of OA policy adoption	X_8
Share of Full OA / Hybrid OA journal articles covered by DEAL contracts	X_9^F/X_9^H
Full OA share / Hybrid OA share in the publication output of German universities	Y^F/Y^H

variable is named dependent variable, and the variables that are assumed to have effects on the dependent variable are called independent variables. In our analysis, separate regression models were calculated for three time periods and two dependent variables each (Full OA share and Hybrid OA share). Given that collinearity of explanatory variables can be a problem for regression analysis, variance inflation factors (VIFs) were calculated for all regression models using the STATA 11 *VIF* function.

The values in Table 5 show that there is some explanatory power between the independent variables but they all are well below the critical value of 5, which is considered as a threshold value above which the model should be adjusted, e.g. by excluding certain independent variables. As a consequence, all considered variables are included in the regression analysis.

Full OA

To begin with the most definite result for Full OA, namely hypothesis F-3 on the influence of the disciplinary profile, H_0 has to be rejected as all simple linear regression models (nos. 3, 6 and 10) show strong effects of the disciplinary influence factor X_1^F on the Full OA share of German universities, and the regression coefficient for the factor can be interpreted as follows: Depending on the period that is considered, the Full OA share of a university raises between 1.295 and 1.338 percent points if the disciplinary influence factor increases by one percent point. The composition of the disciplinary profile is by far the most important variable that alone explains from 73.8% (2020) to 85.7% (2017–2018) of the variance of the dependent variable as the coefficient of determination adj. R^2 of the univariate regression models shows. The strong effect of the disciplinary factor remains even when we control for other possible influences in multiple regression analyses (nos. 1, 4 and 7) including all of the independent variables described before in Section “[Results](#)” (with the exception of the DEAL-related factor, which is discussed below). Therefore, the disciplinary profile is the most determining factor for the uptake of Full OA at German universities. (See Tables 6 and 7).

Regarding Hypothesis F-1, H_0 (‘Universities with a publication fund have a smaller (or equal) OA share than universities without a publication fund’) is rejected for all periods on the 0.05 level of significance and for 2010–2020 and 2020 also on the 0.01 level of significance in the full models. For all years, the existence of a publication fund turns out to have

Table 2 Descriptive statistics for categorical independent variables

Variable	True	True (%)	False	False (%)
X_2 (publication fund)	73	70.2	31	29.8
X_3 (OA officer)	77	74.0	27	26.0
X_4 (webpage with OA information)	87	83.7	17	16.4
X_5 (OA activities)	37	35.6	67	64.4
X_6 (OA rights information)	51	49.0	53	51.0
X_7 (OA policy)	67	64.4	37	35.6

Table 3 Descriptive statistics for metrical independent variables

Variable	Observations	Mean	Std. Dev	Min	Max
X_8 (months of policy adoption, all universities)	104	48.77	53.02	0	179
X_9 (months of policy adoption, universities with OA policy)	67	75.70	48.14	0	179

a small but significant positive effect on the Full OA share. A comparison of the models including the disciplinary influence factor X_1^F and the existence of a publication fund X_2 with the models where the disciplinary influence score X_1^F is the only independent variable, the inclusion of the variable X_2 adds only little explained variance with the strongest effect in the period 2020 (77.1% of the variance explained compared to 73.8% using only the disciplinary factor).

With respect to F-2, H_0 (*Universities that are highly engaged in educating scientists (provision of OA information, organisation of OA events, support of OA officers and OA policies) have a smaller or equal Full OA share than universities with less engagement) cannot be rejected. In all three periods, X_4 (webpage with OA information) turned out to be significant at least at 0.05 level, but the effect points in the direction of H_0 . The same holds for X_3 in the period 2017–2018. In other words, no significant positive effect of the existence of an OA officer, OA webpage, OA rights information and OA training activities on the Full OA share could be established by the regression analysis. When the results of the regression analyses nos. 1, 4 and 7 are compared with the univariate regression analyses nos. 3, 6 and 10, it turns out that the inclusion of the variables of universities’ infrastructures and services shows only small improvements of the explained variance, represented (adj. R^2 value of 0.847 vs. 0.806, 0.877 vs. 0.857, and 0.784 vs. 0.738).

Finally, hypothesis F-4 formulates a conjecture about the influence of transformative agreements, namely the large contracts with SpringerNature and Wiley that were negotiated by project DEAL. These contracts became effective in 2019 and 2020, respectively. The regression analysis provides evidence that H_0 (Universities with a large share of Full OA-articles covered by DEAL transformative agreements, have an equal or a smaller Full OA share than universities with a smaller Full OA share in transformative agreements) has to be rejected and that DEAL has a positive effect on the Full OA share on a 0.05 level of significance when controlling for other factors. However, the added explained variance of

Table 4 Publication-based indicators (independent and dependent variables)

Variable	Observations	Mean	Std. Dev	Min	Max
2010–2020					
Total Publications*	98	6,203.48	6,530.22	54	26,912
Y^F , Full OA (%)*	98	14.48	5.48	0.63	27.38
Y^H , Hybrid OA (%)*	98	5.71	1.80	1.32	11.46
X_1^F , Full OA disciplinary influence factor*	98	12.46	3.69	1.76	20.27
X_1^H , Hybrid OA disciplinary influence factor*	98	6.90	0.79	4.64	8.24
2017–2018					
Total Publications	82	1,481.74	1,310.11	59	5,366
Y^F , Full OA (%)**	82	18.39	6.00	0	34.79
Y^H , Hybrid OA (%)**	82	4.58	1.84	0	8.64
X_1^F , Full OA disciplinary influence factor**	82	15.47	4.37	2.08	25.69
X_1^H , Hybrid OA disciplinary influence factor**	82	6.34	0.79	4.19	7.44
2020					
Total Publications	79	876.95	745.69	55	3,126
Y^F , Full OA (%)***	79	26.20	8.19	7.94	58.15
Y^H , Hybrid OA (%)***	79	21.80	3.79	8.82	30.74
X_1^F , Full OA disciplinary influence factor***	79	22.57	5.45	8.02	39.55
X_1^H , Hybrid OA disciplinary influence factor***	79	24.55	1.51	18.99	27.60
X_9^F , share of Full OA DEAL publications***	79	1.93	1.11	0	5.32
X_9^H , share of Hybrid OA DEAL publications***	79	9.83	3.25	0	15.30

*Universities with a publication output > 50 in 2010–2020, restricted to publications with corresponding authors of that university

**Universities with a publication output > 50 in 2017–2018, restricted to publications with corresponding authors of that university

***Universities with a publication output > 50 in 2020, restricted to publications with corresponding authors of that university

Table 5 Variance inflation factors

	X_1^F	X_1^H	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9^F	X_9^H
<i>Full OA</i>											
2010–2020	1.23	–	1.71	1.70	2.19	1.25	1.44	2.77	2.10	–	–
2017–2018	1.18	–	1.50	1.55	1.99	1.21	1.34	2.41	1.93		
2020	3.50	–	1.40	1.43	1.58	1.21	1.22	1.99	1.80	3.40	–
<i>Hybrid OA</i>											
2010–2020		1.60	1.70	1.66	2.27	1.26	1.42	2.71	2.27	–	–
2017–2018	–	1.41	1.48	1.61	1.73	1.20	1.21	2.05	1.96	–	–
2020	–	1.29	1.39	1.40	1.63	1.18	1.26	1.96	1.91	–	1.27

the Full OA share of universities by the share of publications covered by DEAL is relatively small (additional 1.4% explained variance).

Table 6 Full OA, regression models

Reg	X_1^f	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9^f	F	R ²	Adj. R ²	RMSE
2010–2020													
1	1.349**	0.020**	-0.004	-0.036**	0.006	-0.001	0.007	0.000	-	68.07	0.860	0.847	0.021
2	1.306**	0.014*	-	-	-	-	-	-	-	216.60	0.820	0.816	0.023
3	1.338**	-	-	-	-	-	-	-	-	405.04	0.808	0.806	0.024
2017–2018													
4	1.297**	0.018*	-0.002*	-0.026*	0.004	-0.006	0.004	0.000	-	78.44	0.888	0.877	0.023
5	1.288**	0.016*	-	-	-	-	-	-	-	279.81	0.868	0.865	0.024
6	1.317**	-	-	-	-	-	-	-	-	523.03	0.859	0.857	0.024
2020													
7	1.055**	0.039**	0.010	-0.072*	-0.001	-0.020	0.021	-0.000	1.597*	32.39	0.809	0.784	0.038
8	1.297**	0.037**	-	-	-	-	-	-	-	125.97	0.768	0.762	0.040
9	1.016**	-	-	-	-	-	-	-	1.663*	118.92	0.758	0.752	0.041
10	1.295**	-	-	-	-	-	-	-	-	220.57	0.741	0.738	0.420

*Significant at the 0.05 level; ** significant at the 0.01 level

Table 7 Hybrid OA, regression models

Reg	X_1^H	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9^H	F	R ²	Adj. R ²	RMSE
2010–2020													
11	1.162**	0.004	0.007	-0.003	0.001	0.001	-0.003	0.000	-	8.61	0.436	0.386	0.014
12	1.434**	-	-	-	-	-	-	-	-	62.49	0.394	0.388	0.014
2017–2018													
13	1.480**	0.002	0.000	0.007	0.003	-0.000	0.002	-0.000	-	7.84	0.462	0.403	0.014
14	1.550**	-	-	-	-	-	-	-	-	63.81	0.444	0.437	0.014
2020													
15	0.977**	-0.002	-0.013	0.040	-0.001	-0.000	-0.003	0.000	0.418**	6.07	0.442	0.369	0.030
16	1.043**	-	-	-	-	-	-	-	0.439**	27.07	0.416	0.401	0.029
17	1.356**	-	-	-	-	-	-	-	-	31.50	0.290	0.281	0.032

*Significant at the 0.05 level; ** significant at the 0.01 level

Hybrid OA

Turning to Hybrid OA the results of the regression models are in accordance with those for Full OA but also differ in part. To begin again with hypothesis H-3, H_O ('Universities with a disciplinary profile that shows affinity towards Hybrid OA have a smaller or equal Hybrid OA share than universities with a disciplinary profile with less affinity towards Hybrid OA') can be rejected. According to adj. R^2 , the proportion of the variance explained by the disciplinary influence factor is reasonably large and varies between 28.1% and 43.7%. However, when compared with the Full OA models, it ranges on a much lower level. The regression coefficient shows that the Hybrid OA share increases between 1.356 (period 2010–2020) and 1.550 (2017–2018) percent points if the disciplinary influence score increases by one point.

Regarding the effect of universities' infrastructures and services, all variables (X_2 – X_8) turned out not to be significant in any of the periods analysed. Therefore, our data support neither H-1 ('Universities with a publication fund have a higher Hybrid OA share than universities without a publication fund') nor H-2 ('There is a need for educating scientists regarding the advantages of the APC-liable Hybrid OA model. The stronger a university is engaged in educating scientists (provision of OA information and organisation of OA events, supported by OA officers and OA policies) the larger is the Hybrid OA share').

Finally, the effect of the DEAL transformative agreements was considered for the year 2020. When combined with the disciplinary influence factor X_1^H , the (at 0.01 level) significant DEAL influence factor X_9^H adds 12,0% of explained variance to the model. Hypothesis H-4 ('The larger the share of Hybrid OA articles covered by DEAL, the larger is the overall Hybrid OA share of a university') is therefore supported. In addition, it is interesting to note that the additional explained variance of the DEAL influence factor is much higher in the case of Hybrid OA than in the case of Full OA.

Discussion

In this section, we will summarise the results of the regression analysis and discuss them in the context of interviews that were conducted with OA officers at German universities to deepen the understanding of the uptake of OA.

The most important results can be summarised as follows: Regarding the adoption of both Hybrid and Full OA, the most determining factor is the disciplinary profile of German universities. The more a university's publication output comprises publications from subject fields with a high degree of (Hybrid or Full) OA adaption, the larger is the (Hybrid or Full) OA share of the university. In the interpretation of the results it should be kept in mind that the analysis happens on a high level of aggregation, resulting in at least two limitations: The first one is a consequence of the way in which the disciplinary influence factor is conceptualised. As a highly aggregated factor, it reflects the adoption in all fields of science by a single number. Therefore, it is not possible to attribute differences in the adoption of OA to individual scientific areas, disciplines, specialties or fields. Second, the regressions show that the disciplinary profile is by far the strongest determinant but the actual mechanisms of how the disciplinary publication culture affects the OA share remains unclear. The analysis cannot answer the question whether it is the attitude of scientists in fields with an affinity towards OA, the existence of practices and routines in the context

with OA publication media (Taubert, 2021), the availability of Hybrid or Full OA journals (Severin et al., 2020), or a combination of two or more factors that is decisive here.

Regarding transformative agreements, the effects of the DEAL contracts could be tested for the year 2020 with mixed results. For both OA types, transformative agreements turn out to be a significant factor but the explanatory power differs. In the case of Full OA the factor adds only a small fraction of explained variance compared to a model using just the disciplinary influence factor, while in the case of Hybrid OA the explanatory power of the model is substantially improved. For Hybrid OA, such agreements can be considered as an effective instrument, yielding remarkable results on the level of the university landscape.

Besides the strong effects of the disciplinary profile and transformative agreements (the latter mainly in the case of Hybrid OA), the weak explanatory power of universities' OA infrastructures and services is another noticeable result. Most of the variables of universities' infrastructures and services are not significant in any regression model and those that are significant point in the direction of H_0 or add only tiny fractions to the explained variance. This result should not be interpreted in the way that the build-up of OA infrastructures, staff and services is no effective means to support OA at individual universities. A number of universities could achieve large journal-based OA shares by the provision of good infrastructures and services. However, when analysed on the level of the whole German university landscape, the factors do not explain much. For a more detailed understanding, the different variables of universities' infrastructures and services are discussed and contextualized using the conducted interviews with OA officers in the following.

Publication fund (X_2)

To begin with the existence of a publication fund (X_2), the variable does not have a significant influence on the Hybrid OA share in any of the periods, but it has small explanatory power for the Full OA share in 2020. To better understand this result, it is worth noticing that the build-up of publication funds in Germany was strongly influenced by the programme 'Open Access Publizieren' of the Deutsche Forschungsgemeinschaft. It supported the build-up of 57 publication funds at German universities (Ploder et al., 2020, p.14) and aimed to establish structures at universities that organise the financial flows and monitor the costs for OA. The DFG programme defined criteria for the financial support including a price-cap for APCs charged by Full OA journals and excluding articles in hybrid journals from funding (Ploder et al., 2020, p. 17). The latter criterion explains why the variable has no explanatory power for Hybrid OA shares of German universities. However, for an understanding of a weak or missing explanatory power in the case of Full OA, different aspects have to be considered. First, a number of interviewees confirm that the DFG criteria that were implemented during the build-up of a publication fund are often still applied after DFG funding has expired.¹⁴ One interviewee describes the influence of the DFG programme beyond the funding period as follows:

This year, we are now in the situation to finance our publication fund independently and could define the criteria for funding ourselves. But we did not. We still have the same funding criteria like in 2020 the last year of the DFG-funding of our publication fund. Therefore, the DFG still has a big influence that I find positive. First, a

¹⁴ I-01, pos. 19; I-05, pos. 81; I-06, pos. 111, 121; I-07, pos. 60-61; I-11- pos. 45; I-12, pos. 21, 47; I-16, pos. 19; I-17, pos. 77, I-18, pos. 67.

clear commitment to support Gold OA but not Hybrid OA and a price cap of 2,000€ as a maximum financial support (I-12, pos. 47).

The price-cap of 2000€ may explain that the effect of publication funds is limited as publications in Full OA journals with higher APCs are excluded from support by the publication fund. The restriction may also continue to be effective after DFG funding has expired. However, the sheer number of 12,000 articles that received funding from DFG sources between 2011 and 2017 (Ploder et al., 2020, p.33) would suggest that the effect on the Full OA share of German university landscape would be larger. Hints for an explanation of the limited effects can be derived from the literature. A retrospective analysis of the outcomes of the already mentioned DFG-programme reports similar Full OA shares for the two groups of universities with and without a DFG publication fund (Ploder et al., 2020, p. 42). In addition, in an analysis of the coverage of APC-liable publications of a university in their publication funds, Bruns & Taubert (2021) found out that a considerable part of such payments—varying between 10.4% and 89.0%—were not processed by publication funds but via other channels. Both findings suggest that publication funds are not primarily a financial source that allows scientists to turn additional articles in APC-liable journals OA but, when introduced, are used by scientists to substitute other sources for payments like third party funds or budgets of faculties instead of turning additional articles into OA. This interpretation is also supported by an interviewee who was complemented for the build-up of the publication fund at his university and doubts that the raise of the OA share is an effect of his efforts:

Sometimes I ask myself, if this [the growth of the OA share] is my merit. At the time when our former director retired, he said that I had built up the fund and it is incredible how it is being used by now. I ask myself, if there is actually growth within certain disciplines because of the fund or because of their publication culture. Well, from the beginning there was no need to convince them of Open Access. When we built-up the publication fund, they were the first that used it, and this continued (I-16, pos. 25).

Open access policy (X_7) and month of policy adoption (X_8)

Another instrument for the advancement of OA are institutional OA policies modelled as two variables ('existence of an OA policy' (X_7), 'duration of policy adoption' (X_8)) in the regression analyses. In all regression models for Full and Hybrid OA and for all periods both variables turned out to be non-significant on a 0.05-level. At first glance, these findings contradict studies on a global scale that report high compliance rates of OA policies and mandates also for journal-based OA (Gargouri et al., 2012, Larivière & Sugimoto, 2018, Kirkmann & Haddow, 2020). However, OA policies and mandates vary in strength (Vincent-Lamarre et al., 2016) as OA can either be 'requested' or 'required'. In addition, non-compliance can be but not always is linked to sanctions like the suspending of payments in the case of funder mandates (Larivière & Sugimoto, 2018) or the non-consideration of non-OA publications in research evaluations like, for example, in the case of the institutional OA policy of the University of Liège (Rentier & Thirion, 2011). Both mandate strength and sanctions would support high compliance rates.

Against this background it is less surprising that the OA policies at German universities do not yield strong effects since institutional OA policies in Germany so far do not

formulate mandatory requirements but ‘recommend’ and ‘encourage’ to publish OA with only one known exception. The reason for such soft-style policies is that the German constitution guarantees freedom of research, including the freedom of publication. The results of the bibliometric analysis find their reflection in the statements of OA representatives from the interviews. Nearly all of the interviewees do not see any direct effect of OA policies on the journal-based OA share of their universities, and a number of them explicitly reject such a relation.¹⁵ One example of such a perspective can be found in the interview with I-10 who describes the effects of the introduction of the OA policies at her university as follows:

I would say, it [the OA policy] has minor or no effects. At the time when the policy was new—and the same also holds for the research data policy that we have—I received a number of nervous telephone calls [from scientists]. “We now have to publish OA, how can we do that?” When I explained during the conversation that the character is more a recommendation than a requirement, the callers quickly took leave (I-10, pos. 41).

Given that OA policies do not improve the journal-based OA shares and given that OA officers do not expect such effects, the question arises for what purpose German universities have established those documents. Again, insights from the interviews are helpful to understand the underlying factors and mechanisms: No less than 12 interviewees¹⁶ of the 16 universities with an OA policy from the interview sample reported that the trigger for establishing a policy was the DFG project ‘Open Access Publizieren’. Within the programme, the existence of an OA policy was not a formal requirement but it was regarded as being beneficial for the proposals by the applicants. One OA officer portrays her argument that was convincing for the implementation of an OA policy at her university as follows:

Well, I have said, the DFG wants that [an OA policy] and if the DFG wants that, the scientists want that as well. One wants to have a good standing at the DFG and therefore, I said that it’s no drawback if we have such a thing. Because of this reason, it passed [the committees of the university] without resistance (I-11, pos. 37).

The emergence of many OA policies shows that it responded to external expectations and a demand for legitimation that should increase the chances for the acquisition of resources for the university. However, external legitimation is not the only function OA policies have. It is also a means for legitimising the goal of OA to research internally, as a number of quotations show.¹⁷

I think it is something that the university takes a stand for. This is important for our argument, if we try to promote or support open access and the different publication models of open access [...] But it helps to have such a policy on the level of the university, that was adapted with consensus, to rely on that and to create momentum (I-08, pos. 54).

¹⁵ I-04, pos. 57; I-10, pos. 33, 41,42; I-15, pos. 51, 91; I-16, pos. 49; I-17, pos. 61, I-21, pos. 41.

¹⁶ I-02, pos. 80; I-05, pos. 63; I-08, pos. 7; I-09, pos. 32; I-10, pos. 29; I-11, pos. 37,35, I-12, pos. 35; I-13, pos. 29; I-15, pos. 81, 83; I-17, pos. 61; I-20, pos. 41, 53; I-21, pos.41.

¹⁷ I-01, pos. 59; I-04, pos. 57; I-05, pos. 49; I-08, pos. 54; I-09, pos. 81; I-11, pos. 39; I-15, pos. 91; I-17, pos. 65.

To summarise, evidence from the regression analysis and the interviews underlines that OA policies of German universities do not have a strong direct effect on the journal-based OA publication output. However, their function is more subtle as they help to legitimise the goal of OA internally and position the libraries as being responsible for the provision of services and for the advancement of OA. In addition, OA policies are important means for an external legitimisation that respond to expectations of funders and help to support the flow of resources.

OA officer (X_3)

In management literature, it is stated that an “important element” for organisational change is “represented by a member of staff or delegate [...] serving the need of a clear structure and continuity. This particular stakeholder should be positioned closely to the senior leadership” (Bauer et al., 2018). In the case of the transformation towards OA, an OA officer could play such a role and may act as a stakeholder in favour of OA. Albeit, the regression analyses do not show any significant effects of the existence of an OA officer in the direction of H_1 for Hybrid as well as for Full OA in any of the periods. This result is open to two interpretations. First, individual OA officers may provide information, support and resources to scientists of their institution, but the effect of their efforts of making publications OA is too small to be significant on the level of the German university system. Before accepting this interpretation, one should also consider the possibility of an oversimplified operationalisation of the variable in the regression analysis. Second, the interviews provide evidence that there is a large variance in the way in which the responsibility for OA is incorporated into the role structure of universities. On the one side of the spectrum where an OA officer exists, he or she is the only person who is responsible for OA and related services and tasks. An example is I-19, an OA officer at a large university who describes his position as follows:

Actually, I am alone. Well we only have me as an OA representative but not an OA office or something and we do not have any staff in that matter (I-19, pos. 8).

On the other side, there are universities with a highly differentiated role structure and a considerable number of staff, each of them being responsible for different OA services:

Virtually, there are three OA-centres at our university. Gold OA in the acquisition section including the transformation budget. The section ‘publication and e-learning services’ runs not only our repositories, which also includes an image database that is partially OA, but also an OJS-system that is much recommended to the scientists especially in the context of specialised information services (Fachinformationsdienste). And in the field of e-learning we also started a project for the hosting of open educational resources (I-08, pos. 12).

For the regression analysis, the universities of I-19 and I-08 show the same value of the binary variable. In addition, the standing of the OA officer regarding the university leaders may also vary and such differences are also not reflected by the variable. Hence, based on the evidence presented here it cannot be decided if a more differentiated operationalisation of OA professionals at German universities would have resulted in a larger share of explained variance.

Webpage with OA information (X_4), information about OA activities (X_5) OA rights information (X_6)

As already shown in the section on descriptive statistics (Section “[Publication fund \(\$X_2\$ \)](#)”), German university libraries use a number of channels to inform and train their scientists about OA. These include web pages with OA information (X_4), web pages with OA rights information (X_6) and other OA activities (X_5) like courses, talks and events. Again, none of the variables are significant for either of the OA types and periods with the exception of the existence of webpages with OA information, which is significant but points in the direction of H_0 .¹⁸ In the case of information provided on websites, the interviews do not help to understand these results: Although addressed by questions in the interview guideline, neither information about OA nor OA rights information on websites were met with much interest of the interviewees. Most of them pointed to the existence of such pages and explained the content but had difficulties in answering the question as to what extent the provided information is used and whether it has effects on OA publishing. One example is interviewee I-21 who comments on the website of her library as follows:

For all of our disciplines we have a webpage with discipline-specific information and hints to important databases and so on. And there, we also have the bullet point “Open Access publication in your discipline” so that people who visit the page look into such things. These are probably not so many, but anyway they received a hint on BASE¹⁹ on repositories and so on via that way (I-21, pos. 87).

This is somewhat in contrast to the passages in which the interviewees are being asked about OA activities like training courses and events, a topic that is discussed at length with diverse perspectives. On the one hand, a number of interviews report (and also complain about) a missing interest of scientists in OA courses and events organised by the library. This is evidenced by the small number of participants that attend such events.²⁰

That is always the question. How are the talks attended? Usually by a single-digit number. Somehow five to seven participants. We are a small university, though” (I-02, pos. 124).

Well it could be more. I would say it is constant, that I always have two or three participants, with the exception of requested seminars, where there are more (I-04, pos. 75).

Both quotations suggest that OA activities like training and events do not attract many participants and may therefore not have strong effects on the shares of journal-based OA. On the other hand, a contrastive perspective can be found in other interviews that report much interest from scientists and draw a more impactful picture about OA training courses.

The [OA] workshops that I teach cannot be provided each month. They are always fully booked and we have to develop the concept a bit because of the limited number of participants that are allowed. [...] There are 35 participants allowed in the

¹⁸ The coefficient of the variable is negative, suggesting that the provision of OA information on a website leads to a smaller Full OA share.

¹⁹ I-21 refers to the Bielefeld Academic Search Engine (<https://www.base-search.net/>, accessed March 22th, 2023) here that allows to search for OA publications.

²⁰ I-01 pos. 67, I-04, pos. 75; I-07, pos. 67; I-11, pos. 60; I-16, pos. 81; I-09, pos. 115; I-19, pos. 143; I-21, pos. 81.

workshops because the participants have to show active participation as they receive ECTS credit points for it (I-06, pos. 7).

And in the case of courses for doctoral students there can be 40 plus participants. Courses that are addressed to scientists, I always say that if the number of participants is two-digit, I am fine (I-08, pos. 92).

A systematic comparison of well and less attended OA courses point to conceptual differences between the two. In the interviews it is reported that courses that are provided proactively by libraries usually yield less attention and smaller audiences than courses, talks and workshops that are delivered upon request.²¹ Such requests typically originate from organisational entities within the universities like institutes, faculties, graduate centres and programmes or from academic bodies.²²

The interviews illustrate a large diversity both in the frequency and in the way the courses are conceptualised by university libraries. For the impact of such activities, the interviews suggest that it is decisive if they are part of a proactive teaching programme of libraries or provided on request and if general or subject specific information are provided by them. Therefore, it is possible that the regression analysis might have yielded more meaningful results if the factor 'OA activity' would have been operationalised with a more differentiated and complex set of variables.

Finally, we would like to discuss one essential limitation of the analysis: The study is restricted to German universities and hence provokes the question, whether anything can be learned for other countries. We think that further research is necessary for other countries but before it is at hand, some assumptions can be drawn from the results presented here. Our first consideration refers to the evidence that there are disciplinary patterns of the adaption of OA that are not restricted to a particular country (Piwovar et al., 2018; Dalton et al., 2020; Severin et al., 2020; Robinson-Garcia et al., 2020; Björk & Korkeamäki, 2020). The strong explanatory power of the disciplinary profile in our models together with the evidence of disciplinary differences on a worldwide level suggest that it is likely that the disciplinary profile might be a relevant determinant in the case of other types of institutions and also in other countries. Second, Germany is not unique in having transformative agreements with large publishers and an extensive coverage of the institutional landscape. Such contracts also exist in other countries. Given that the large publishing houses account for a large share of the publication output worldwide (Larivière et al., 2015), we would expect significant effects of large transformative agreements also for other countries. The third thought refers to OA policies as the situation is unique for German universities. In this country, freedom of science is guaranteed by the constitution (Art. 5 III Grundgesetz). Publication is protected by this right, and no strong top-down regulations like mandates that enforce OA exist for German universities. It is likely that for institutions with stronger regulations the effects will be different than the results reported for German universities.

²¹ I-02, pos. 122, pos. 124; I-06, pos. 7, pos. 16-19; I-08, pos. pos. 92I-12, pos. 73; I-17, pos. 87; I-20, pos. 11, pos. 99, I-16, pos. 75, 81.

²² I-16, pos. 75; I-02, pos. 122.

Conclusion

This article asked the question as to what factors explain the differences in the uptake of journal-based OA in the German university landscape and distinguished in the analysis between Full OA and Hybrid OA. For both OA types the most determining factor for the differences in the OA shares is the disciplinary profile: The more a university's publication output comprises publications from subject fields with a high degree of (Hybrid or Full) OA adaption, the larger is the (Hybrid or Full) OA share of the university.

In 2020, and especially for Hybrid OA, a second factor comes into play, namely the large transformative agreements that were negotiated between project DEAL and Springer-Nature, and Wiley respectively. The share of the publication output of universities covered by such contracts is a factor that adds a considerable amount to the explanatory power of the regression models. Even though transformative agreements are met with scepticism for a number of reasons, including the costs, distributional effects within the German research system and their focus on the three largest publishers that have contributed a lot to the serials crisis in the past, the analysis shows that they are an effective means for the OA transformation with impact on the landscape as a whole.

In contrast, all variables that reflected the infrastructural support and services for OA on the level of universities turned out to be non-significant or did not contribute much to the explained variance. This result should not be interpreted in the sense that infrastructure and support cannot improve the OA share of individual universities. However, the effects are too small to manifest themselves on the level of the entire German university landscape. By contextualising the quantitative analysis with evidence from expert interviews with OA officers from a sample group of German universities, the background about the non-significance of different variables could be explored. In the case of the publication fund, the results suggest that the additional funds are primarily being used by scientists to replace money for APCs from other sources, while for OA policies the interviews show that they have a legitimating function in the first place, instead of directly influencing the OA share. For other variables like 'OA-officer', the provision of OA (rights) information and OA-training and awareness activities, it could not be decided if the variables actually do not influence the journal-based OA share or if they are not significant because of an oversimplified operationalisation in this regression analysis.

Funding Open Access funding enabled and organized by Projekt DEAL. This work was supported by the German Federal Ministry of Education and Research within the funding stream "Quantitative research on the science sector", project OAUNI (grant numbers 01PU17023A and 01PU17023B).

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Agasisti, T., & Pohl, C. (2012). Comparing German and Italian public universities: Convergence or divergence in the higher education landscape? *Managerial and Decision Economics*, 33(2), 71–85. <https://doi.org/10.1002/mde.1561>
- Archambault, É., Amyot, D., Deschamps, P., Nicol, A., Provencher, F., Rebout, L., & Roberge, G. (2014). Proportion of open access papers published in peer-reviewed. Journals at the European and World Levels—1996–2013. *Science Metrix*. <https://digitalcommons.unl.edu/scholcom/8>
- Barbers, I., Stanzel, F., & Mittermaier, B. (2022). Open access monitor Germany: Best practice in providing metrics for analysis and decision-making. *Serials Review*, 48(1–2), 49–62. <https://doi.org/10.1080/00987913.2022.2066968>
- Bauer, M., Bormann, I., Kummer, B., Niedlich, S., & Rieckmann, M. (2018). Sustainability governance at universities: Using a governance equalizer as a research heuristic. *Higher Education Policy*, 31(4), 491–511. <https://doi.org/10.1057/s41307-018-0104-x>
- Bjork, B.-C., & Korkeamaki, T. (2020). *Adoption of the open access business model in scientific journal publishing: A cross-disciplinary study* (arXiv:2005.01008). arXiv. <https://doi.org/10.48550/arXiv.2005.01008>
- Boselli, B., & Galindo-Rueda, F. (2016). Drivers and implications of scientific open access publishing: Findings from a Pilot OECD international survey of scientific authors. *OECD*. <https://doi.org/10.1787/5jlr2z70k0bx-en>
- Bosman, J., & Kramer, B. (2018). Open access levels: A quantitative exploration using Web of Science and oaDOI data. *PeerJ Inc*. <https://doi.org/10.7287/peerj.preprints.3520v1>
- Bruns, A., Lenke, C., Schmidt, C., & Taubert, N. (2020). *ISSN-matching of gold OA journals (ISSN-GOLD-OA) 4.0*. Bielefeld University. <https://pub.uni-bielefeld.de/record/2944717>
- Bruns, A., & Taubert, N. (2021). Investigating the blind spot of a monitoring system for article processing charges. *Publications*, 9(3), Article 3. <https://doi.org/10.3390/publications9030041>
- Bruns, A., Irvani, E., & Taubert, N. (2022). *Open access-related infrastructures and services at German universities (OARIS)*. <https://pub.uni-bielefeld.de/record/2965623>
- Collins, K. M. T., Onwuegbuzie, A. J., & Jiao, Q. G. (2006). Prevalence of mixed-methods sampling designs in social science research. *Evaluation & Research in Education*, 19(2), 83–101. <https://doi.org/10.2167/eri421.0>
- Dalton, E. D., Tenopir, C., & Björk, B.-C. (2020). Attitudes of North American academics toward open access scholarly journals. *Portal: Libraries and the Academy*, 20(1), 73–100. <https://doi.org/10.1353/pla.2020.0005>
- Donner, P., Rimmert, C., & van Eck, N. J. (2020). Comparing institutional-level bibliometric research performance indicator values based on different affiliation disambiguation systems. *Quantitative Science Studies*, 1(1), 150–170. https://doi.org/10.1162/qss_a_00013
- Deutsche Forschungsgemeinschaft | AG Publikationswesen. (2022). *Open-Access-Publikationskosten. Antragseingang und Entscheidungen im Jahr 2021* (accessed March 23th 2023). https://www.dfg.de/download/pdf/foerderung/programme/lis/bericht_oa_publicationskosten.pdf
- Freedman, D. A. (2009). *Theory and practice*. Cambridge Core; Cambridge University Press. <https://doi.org/10.1017/CBO9780511815867>
- Gargouri, Y., Lariviere, V., Gingras, Y., Brody, T., Carr, L., & Harnad, S. (2012). *Testing the finch hypothesis on green OA mandate ineffectiveness* (arXiv:1210.8174). arXiv. <https://doi.org/10.48550/arXiv.1210.8174>
- Greussing, E., Kuballa, S., Taddicken, M., Schulze, M., Mielke, C., & Haux, R. (2020). Drivers and obstacles of open access publishing. A qualitative investigation of individual and institutional factors. *Frontiers in Communication*. <https://doi.org/10.3389/fcomm.2020.587465>
- Haucap, J., Moshgbar, N., & Schmal, W. B. (2021). The impact of the German ‘DEAL’ on competition in the academic publishing market. *Managerial and Decision Economics*, 42(8), 2027–2049. <https://doi.org/10.1002/mde.3493>
- Hobert, A., Jahn, N., Mayr, P., Schmidt, B., & Taubert, N. (2021). Open access uptake in Germany 2010–2018: Adoption in a diverse research landscape. *Scientometrics*, 126(12), 9751–9777. <https://doi.org/10.1007/s11192-021-04002-0>
- Huang, C.-K., Neylon, C., Hosking, R., Montgomery, L., Wilson, K. S., Ozaygen, A., & Brookes-Kenworthy, C. (2020). Evaluating the impact of open access policies on research institutions. *ELife*, 9, e57067. <https://doi.org/10.7554/eLife.57067>
- Jahn, N., Matthias, L., & Laakso, M. (2022). Toward transparency of hybrid open access through publisher-provided metadata: An article-level study of Elsevier. *Journal of the Association for Information Science and Technology*, 73(1), 104–118. <https://doi.org/10.1002/asi.24549>

- Kindling, M., Martin, L., Neufend, M., & Wenninger, A. (2022). Open access atlas Deutschland: Status Quo in Bund und Ländern. Zenodo. <https://doi.org/10.5281/zenodo.6472672>
- Kirkman, N., & Haddow, G. (2020). *Compliance with the first funder open access policy in Australia*. University of Borås (accessed March 23th 2023). <http://informationr.net/ir/25-2/paper857.html>
- Laakso, M., & Björk, B.-C. (2012). Anatomy of open access publishing: A study of longitudinal development and internal structure. *BMC Medicine*, 10(1), 124. <https://doi.org/10.1186/1741-7015-10-124>
- Larivière, V., Haustein, S., & Mongeon, P. (2015). The oligopoly of academic publishers in the digital era. *PLOS ONE*, 10(6), e0127502. <https://doi.org/10.1371/journal.pone.0127502>
- Larivière, V., & Sugimoto, C. R. (2018). Do authors comply when funders enforce open access to research? *Nature*, 562(7728), 483–486. <https://doi.org/10.1038/d41586-018-07101-w>
- Martín-Martín, A., Costas, R., van Leeuwen, T., & Delgado López-Cózar, E. (2018). Evidence of open access of scientific publications in Google scholar: A large-scale analysis. *Journal of Informetrics*, 12(3), 819–841. <https://doi.org/10.1016/j.joi.2018.06.012>
- Mayring, P. (2015). Qualitative content analysis: Theoretical background and procedures. In A. Bikner-Ahsbals, C. Knipping, & N. Presmeg (Eds.), *Approaches to qualitative research in mathematics education: Examples of methodology and methods* (pp. 365–380). Netherlands: Springer. https://doi.org/10.1007/978-94-017-9181-6_13
- Momeni, F., Dietze, S., Mayr, P., Biesenbender, K., & Peters, I. (2022). *Which factors drive open access publishing? A Springer nature case study* (arXiv:2208.08221). arXiv. <https://doi.org/10.48550/arXiv.2208.08221>
- Piwowar, H., Priem, J., Larivière, V., Alperin, J. P., Matthias, L., Norlander, B., Farley, A., West, J., & Haustein, S. (2018). The state of OA: A large-scale analysis of the prevalence and impact of open access articles. *PeerJ*, 6, e4375. <https://doi.org/10.7717/peerj.4375>
- Piwowar, H., Priem, J., & Orr, R. (2019). *The Future of OA: A large-scale analysis projecting Open Access publication and readership* (p. 795310). bioRxiv. <https://doi.org/10.1101/795310>
- Ploder, M., Streicher, J., Sauer, A., Holzinger, F., Dvornak, M., Barbers, I., Mittermaier, B., Rosenberger, S., Scheidt, B., Meier, A., Glänzel, W., & Thijs, B. (2020). DFG funding programme open access publishing—report about the funding. Deutsche Forschungsgemeinschaft. <https://doi.org/10.5281/zenodo.4486411>
- Pölonen, J., Laakso, M., Guns, R., Kulczycki, E., & Sivertsen, G. (2020). Open access at the national level: A comprehensive analysis of publications by Finnish researchers. *Quantitative Science Studies*, 1(4), 1396–1428. https://doi.org/10.1162/qss_a_00084
- Rentier, B., & Thirion, P. (2011). *The Liège ORBi model: Mandatory policy without rights retention but linked to assessment processes*. Berlin 9 Pre-conference on Open Access policy development Workshop (accessed March 23th 2023). <https://orbi.uliege.be/handle/2268/102031>
- Rimmert, C., Schwechheimer, H., & Winterhager, M. (2017). *Disambiguation of author addresses in bibliometric databases—technical report*. <https://pub.uni-bielefeld.de/record/2914944>. (accessed March 23th 2023)
- Robinson-Garcia, N., Costas, R., & van Leeuwen, T. N. (2020). Open access uptake by universities worldwide. *PeerJ*, 8, e9410. <https://doi.org/10.7717/peerj.9410>
- Rowley, J., Johnson, F., Sbaifi, L., Frass, W., & Devine, E. (2017). Academics' behaviors and attitudes towards open access publishing in scholarly journals. *Journal of the Association for Information Science and Technology*, 68(5), 1201–1211. <https://doi.org/10.1002/asi.23710>
- Schimmer, R., Geschuhn, K. K., & Vogler, A. (2015). Disrupting the subscription journals' business model for the necessary large-scale transformation to open access. Max Planck Society. <https://doi.org/10.17617/1.3>
- Science-Matrix. (2018). Open access availability of scientific publications. *Science-Matrix* (accessed March 23th 2023). <https://www.science-matrix.com/open-access-availability-of-scientific-publications/>
- Severin, A., Egger, M., Eve, M. P., & Hürlimann, D. (2020). Discipline-specific open access publishing practices and barriers to change: An evidence-based review. *F1000Research*, 7, 1925. <https://doi.org/10.12688/f1000research.17328.2>
- Smith, A. C., Merz, L., Borden, J. B., Gulick, C. K., Kshirsagar, A. R., & Bruna, E. M. (2021). Assessing the effect of article processing charges on the geographic diversity of authors using Elsevier's "Mirror Journal" system. *Quantitative Science Studies*, 2(4), 1123–1143. https://doi.org/10.1162/qss_a_00157
- Suber, P. (2012). **Open Access**. MIT Press (accessed March 23th 2023). <https://dash.harvard.edu/handle/1/10752204>
- Taubert, N. (2021). Green open access in astronomy and mathematics: The complementarity of routines among authors and readers. *Minerva*, 59(2), 173–194. <https://doi.org/10.1007/s11024-020-09424-3>

- Tenopir, C., Dalton, E. D., Christian, L., Jones, M. K., McCabe, M., Smith, M., & Fish, A. (2017). Imagining a gold open access future: Attitudes behaviors and funding scenarios among authors of academic scholarship. *College and Research Libraries*. <https://doi.org/10.5860/crl.78.6.824>
- Vincent-Lamarre, P., Boivin, J., Gargouri, Y., Larivière, V., & Harnad, S. (2016). Estimating open access mandate effectiveness: The MELIBEA score. *Journal of the Association for Information Science and Technology*, 67(11), 2815–2828. <https://doi.org/10.1002/asi.23601>
- Wohlgemuth, M., Rimmert, C., & Taubert, N. C. (2017). *Publikationen in Gold-Open-Access-Journalen auf globaler und europäischer Ebene sowie in Forschungsorganisationen* [Report]. <https://pub.uni-bielefeld.de/record/2912807>
- Zhu, Y. (2017). Who support open access publishing? Gender, discipline, seniority and other factors associated with academics' OA practice. *Scientometrics*, 111(2), 557–579. <https://doi.org/10.1007/s11192-017-2316-z>