

# Determinants of Article Processing Charges for Hybrid and Gold Open Access Journals

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**Determinants of Article Processing Charges for Hybrid and  
Gold Open Access Journals**

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## **Determinants of Article Processing Charges for Hybrid and Gold Open Access Journals**

### **Abstract**

**Purpose**—While the number of hybrid journals has increased with the conversion from subscription journals, article processing charges have not been examined as frequently as gold open access journals. This study compared the factors affecting article processing charges for hybrid and gold open access journals by formulating a charge equation.

**Design/methodology/approach**—This study examined the article processing charges for 1,354 hybrid and gold open access journals in the Springer imprint. Using the ordinary least squares method, it investigated the determinants of charges, including the relationship between subscription prices and article processing charges for hybrid journals.

**Findings**—The results revealed that the charges set by hybrid journals were higher than those set by gold open access journals by 1,620 USD, after controlling for other variables. A reason could be the oligopolistic market structure of the leading publishers. Although the publisher imprint set the article processing charges based on the journal characteristics, the difference in the determinants of the charges between the two journal types may be due to the business models specific to the journal types.

**Originality/value**—This study examined the relationship between subscription prices and charges for hybrid journals as well as the determinants of charges for both journal types, considering various characteristics of individual journals.

**Research implications**—The findings suggested that policymakers must consider the market power of leading publishers to establish a healthy scholarly communication market.

**Keywords:** hybrid journal, gold open access journal, article processing charge, Springer

imprint

Paper type: Original article

## **1. Introduction**

The development of open access journals can be attributed to the increased Internet penetration, rising prices for subscription journals, and the idea that free access to peer-reviewed journal literature accelerates research (Budapest Open Access Initiative, 2002). Moreover, several funders, such as UK Research and Innovation (formerly Research Councils UK) and cOAlition S (a consortium of research funders that established Plan S), mandate that authors publish funded research in open access journals. Accordingly, leading publishers have launched fully open access journals called gold open access journals and converted their subscription journals to hybrid journals, which provide authors with open access options. Whereas hybrid journals usually have both print and electronic versions, gold open access articles are electronically distributed.

Authors and their research institutes must pay article processing charges (APCs) to publish open access articles in APC-funded gold open access journals and hybrid journals. Asai (2021) and Khoo (2019) reported that APCs for gold open access journals tend to increase with time, which raises the financial burden on authors and their institutes. Furthermore, Asai (2019; 2020) and Siler and Frenken (2020) examined the factors affecting the levels of APCs for gold open access journals by formulating an APC equation and found that APCs were higher for journals with high citation scores. However, due to the lack of data on most publishers, their analysis did not consider the demand for journals, which may determine APCs. Therefore, there is room to elaborate on these studies. One purpose of the current study was to examine the determinants of APCs using the number of article downloads; a higher number of article downloads represents greater journal demand from readers.

Over the last several years, the number of hybrid journals has increased (Björk, 2017;

Universities UK, 2017), but the research on APCs for hybrid journals is still inadequate. This could be because many hybrid journals were initially subscription journals published by the “Big 5” leading for-profit publishers—Elsevier, Sage, Springer Nature, Taylor & Francis, and Wiley (Kim and Park, 2020). The hybrid journal market has not changed significantly when compared with the gold open access journal market with several newly launched entries (e.g., PLOS). Moreover, whereas most articles in hybrid journals are closed, all articles in gold open access journals are freely accessible. Therefore, researchers of open access tend to pay less attention to hybrid journals than gold open access journals. Additionally, whereas APCs for gold open access articles vary across journals, prices for most hybrid journals were initially set at approximately 3,000 USD (Björk, 2012; Björk and Solomon, 2014). According to Björk (2012), when Springer (the present Springer Nature) launched hybrid journals in 2004, it set its APCs at 3,000 USD based on the average cost of publishing an article. Other leading publishers that followed Springer also set this as their APCs and thus 3,000 USD became the standard APC for hybrid journals. As there were no major discrepancies in the APCs across hybrid journals, it did not attract significant scholarly attention.

However, leading publishers have recently set different APCs across hybrid journals according to journal characteristics. As hybrid journals tend to have large citation scores (Piwowar *et al.*, 2018), authors who are required to publish their articles in open access by research funders are inclined to submit them to prestigious hybrid journals. Therefore, the levels of APCs for hybrid journals influence open access development significantly. Moreover, Björk’s (2012) explanation of the initial APC suggested that APCs for hybrid journals were related to the subscription prices. If this aspect remains true, then APCs for hybrid journals would keep on increasing with the rise in subscription prices. Therefore, it is worth investigating the relationship between hybrid journals’ APCs and subscription prices to discuss future APCs.

Some studies found that the mean APC for hybrid journals was higher than for gold

open access journals (Jahn and Tullney, 2016; Pinfield *et al.*, 2017; Universities UK, 2017). Budzinski *et al.* (2020) and Schönfelder (2020) revealed similar findings by formulating an APC equation for hybrid and gold open access journals. However, the two studies did not consider the number of downloads and the subscription prices. Therefore, this study examined the relationship between APCs for hybrid journals and subscription prices as well as the determinants of APCs for both hybrid and gold open access journals using variables representing various journal characteristics.

This study focused on the characteristics of individual journals, specifically, the number of times articles were downloaded; however, only some publishers share the data. One such publisher is the Springer imprint, an imprint of Springer Nature, a well-known global publisher. Therefore, this study examined the imprint journals. Additionally, targeting imprint journals eliminated the potential differences in APC settings that depend on publishers and imprints. Although this study's results cannot be generalized to the overall open access market, its research approach enabled a detailed investigation of APC determinants for hybrid and gold open access journals. Thus, it contributes to the literature on the constructive growth of the academic journal market.

## **2. Related Literature**

This study's design is based on the methods and findings of previous studies that examined the prices for subscription journals and APCs for open access journals. Petersen (1990) used the number of issues and pages per year, advertising, publisher type, and academic fields as independent variables in a price equation to examine the determinants of subscription prices, and revealed that library prices of journals published by for-profit publishers were higher than those published by non-profit associations. Subsequently, Petersen (1992) examined the subscription prices of economic journals using the number of circulations and citations, and region of journal publication, in addition to the variables in Peterson (1990) and reported that more frequently cited journals set higher prices.

Similarly, Chressanthis and Chressanthis (1994) used the number of pages and issues per year, impact factor, publisher type, region of journal publication, and the number of circulations to examine the library prices of economic journals and found that publishers enjoyed economies of scale. The estimation method by Petersen (1990, 1992) and Chressanthis and Chressanthis (1994) was ordinary least squares (OLS).

When Dewatripont *et al.* (2007) formulated a subscription price equation using the number of citations and articles, impact factor, publisher type, and academic fields to examine the determinants of subscription prices in various academic fields, they used OLS and the instrumental variables method to accommodate the possibility of endogeneity between subscription prices and citations. However, there were no significant differences in the estimated coefficients of variables between the two estimation methods. Based on the estimation results, Dewatripont *et al.* (2007) concluded that for-profit publishers set higher prices than academic societies and that the number of citations affected prices positively. Liu (2011) investigated the prices of subscription journals for business studies using variables such as the number of issues released per year, years since the journal's inception, advertising, and publisher type, and found that for-profit publishers tended to set higher prices. Moreover, when Liu and Gee (2017) investigated subscription journal prices in science, technology, and medicine using the same variables as Liu (2011), they found that for-profit publishers overcharged libraries. Coomes *et al.* (2017) examined the subscription prices of geography journals using the number of articles and citations, publisher type, number of years since the journal's inception, and publisher's market share. Coomes *et al.* (2017) revealed that for-profit publishers with large journal market shares tended to set higher prices. OLS was used to estimate the price equation in Liu (2011), Liu and Gee (2017), and Coomes *et al.* (2017).

Although Petersen (1992) and Chressanthis and Chressanthis (1994) used the number of circulations, which represents demand for a subscription journal, as an independent variable, as Bergstrom (2001) pointed out, for-profit publishers did not make their

circulation data public after the year 2000. Certainly, empirical studies conducted since the 2000s on subscription prices did not use the number of circulations. The lack of data posed an obstacle to examining subscription prices in detail.

Regarding gold open access journals, the APCs for journals in science, technology, and medicine tended to be higher than those in social sciences as well as arts and humanities, indicating that APCs differed among academic fields (Crawford, 2020; Solomon and Björk, 2012). Romeu *et al.* (2014) found that the correlation between APCs for gold open access journals and the impact factors was positive at 0.71. Furthermore, Björk and Solomon (2015) reported a positive correlation coefficient between APCs and citation indexes in Scopus (established by Elsevier) in 2011. This was also affirmed by Pinfield *et al.* (2017), whose findings showed that the correlation between the APCs applied in 2014 and the citation score was 0.90.

In addition to the correlation coefficient, recent studies have identified the determinants of APCs for gold open access journals by formulating an APC equation. Asai (2019) investigated the APCs that were applied in 2018 to BMC (formerly BioMed Central) journals using a sample selection model and found that BMC set higher charges for more frequently cited open access journals. Subsequently, Asai (2020) used the number of articles, citation scores, publisher type, market share of the publisher, number of years since the journal's inception, and academic fields as independent variables, and simultaneously formulated an APC equation along with the equations of citation scores and number of articles to accommodate the possibility of endogeneity of variables. Asai (2020) concluded that publishers tended to set higher APCs for more frequently cited open access journals with a higher number of articles. Siler and Frenken (2020) used the language in which a journal was published, publisher type, impact factor, region of journal publication, number of articles, and academic fields to examine APCs for gold open access journals using OLS, and revealed that APCs for journals written in English, published in wealthier regions were higher.

Although Asai (2019; 2020) and Siler and Frenken (2020) examined the APCs for only gold open access journals, several studies analyzed the APCs for both hybrid and gold open access journals. Jahn and Tullney (2016), Pinfield *et al.* (2017), and Universities UK (2017) found that the mean APC for hybrid journals was higher than those for gold open access journals. Barbers *et al.* (2018) investigated APC expenditures by a library in 2017 and reported that APCs for Springer's hybrid journals were 1.4 times higher than those for its gold open access journals. Maddi and Sapinho (2022) concluded that APCs for hybrid journals were 50% higher than those for gold open access journals by investigating 4,751 journals published by 267 publishers.

Schönfelder (2020) examined the APCs for hybrid and gold open access journals using citation scores, publisher, academic fields, and a binary variable representing whether the journal is hybrid. Using OLS, Schönfelder (2020) found that the APCs for hybrid journals were higher than those for gold open access journals and that the positive effect of citation scores on the APCs for gold open access journals was larger than that for hybrid journals. Furthermore, Schönfelder (2020) found that Elsevier and Springer Nature set higher APCs than PLOS and Oxford University Press after controlling citation score and academic disciplines. When Budzinski *et al.* (2020) examined APCs for the two journal types using OLS, they chose impact factors, publisher type, number of years since the journal's inception, number of articles, the sum of the square of each publisher's citation shares within a discipline, and a binary variable of hybrid as independent variables. Based on the results of an APC equation, Budzinski *et al.* (2020) concluded that market concentration played an important role in determining APCs. Although Budzinski *et al.* (2020) and Schönfelder (2020) were pioneering studies, they did not examine the influence of journal demand from readers on APCs and the relationship between APCs for hybrid journals and subscription prices. Thus, regarding previous studies that examined APCs for hybrid and gold open access journals, there is room for refining the estimation equation by adding variables that represent journal characteristics.

### **3. Research Questions**

This study investigated the following research questions:

1. Are APCs for hybrid journals higher than those for gold open access journals, after controlling for other variables?

This study compared APCs between hybrid and gold open access journals, considering various characteristics of individual journals.

2. Does the demand for the journal from readers influence the APCs for hybrid and gold open access journals?

Although previous studies overlooked this matter, this study used the number of downloads, which represents journal demand, as an independent variable in the APC equation.

3. Are APCs for hybrid journals associated with subscription prices?

According to Bosch *et al.* (2020), subscription prices tend to increase. If the two prices have a positive relationship, APCs will increase with subscription prices, which will increase the financial burden on authors and university libraries.

### **4. Method**

#### *Target Journals*

This study focused on hybrid and gold open access journals published by the Springer imprint for three reasons. First, the setting of APCs might differ across imprints within a given publisher. Leading publishers, such as Elsevier and Springer Nature, have acquired several imprints through mergers with others. Springer Nature's journals include Springer, BMC, Nature Research, Palgrave Macmillan, and other imprints. Although the BMC imprint has many gold open access journals, it does not publish any hybrid journals. By contrast, the Springer imprint contains many hybrid journals, although the number of gold open access journals was smaller than that of BMC. Journals that have co-publishers were

not included to exclude their influences. Second, the Springer imprint launched hybrid journals ahead of other publishers and has a long business history. Therefore, the imprint has critical experience in setting APCs for hybrid journals. Lastly, the Springer imprint provides the number of downloads for individual journals, which indicates journal demand from readers, although other major publishers, such as Elsevier, do not provide these data. This study examined the APCs for 1,293 hybrid and 61 gold open access journals published in English and indexed in Scopus. As several gold open access journals in Scopus, published on behalf of research institutes, do not impose any APCs, they were excluded from the study sample.

### *Model*

This study constructed equation (1) for hybrid and gold open access journals. The dependent variable *APC* was defined as the APC for research articles that were accepted in 2021, expressed in USD. The number of downloads and subscription prices were independent variables specific to this study, whereas the number of articles, citation scores, number of years since the journal's inception, academic fields, and journal type (hybrid or gold) were similar to those in previous studies. In the second half of 2020, Springer Nature announced APCs that were effective from January 2021. This study assumed that the publisher used the citation scores, the number of downloads, and the number of articles in a journal in 2019, which were the latest data available in 2020, to determine the APCs to be applied in 2021. Therefore, this study used the 2019 values of these three variables. However, the subscription prices applicable in 2021 were used to examine the relationship between subscription prices and APCs for hybrid journals. The independent variable *Download* comprised the number of downloads in 2019, and the data are available on the journal websites. *Article* was defined as the number of documents published in a journal in 2019. *CiteScore* in 2019 denoted the number of citations from 2016 to 2019 divided by the number of documents in the same period. *Year* was defined

as the number of years since the journal's inception (2021=1). *Subscription Price* represented the institutional price for the electronic version of hybrid journals applied in 2021, expressed in USD.

Asai (2019) used a sample selection model to examine the determinants of APCs for BMC journals because several BMC journals did not charge any *APCs*. In contrast, as all authors in this study need to pay APCs to publish their articles in open access, a sample selection model is not applied. Although the number of downloads and articles, as well as the citation scores in 2019, were determined before the APCs effective from January 2021 were set, this study checked whether these variables were exogenous or endogenous by the Hausman test. When *CiteScore* was assumed to be endogenous, this study estimated *CiteScore* using other exogenous variables and the past *CiteScore* as instrument variables. Next, it estimated the *APC* equation by adding the error term in the *CiteScore* equation as a variable. When the null hypothesis that the coefficient of the error term is equal to zero is not rejected, the variable is exogenous. As the null hypothesis that the coefficient of the error term is equal to zero was not rejected at the 10% significant level, this study concluded that *CiteScore* was not endogenous. The same method was applied to *Download*, *Article*, and *Subscription Price*. As the null hypothesis for the coefficients of error terms for the three variables was not rejected at the 10% significance level, they were confirmed to be exogenous. Therefore, this study estimated equation (1) using OLS, which was the same method as Budzinski *et al.* (2020), Schönfelder (2020), and Siler and Frenken (2020) used.

$$APC_t = f(Download_{t-2}, Article_{t-2}, CiteScore_{t-2}, Year, Subscription Price_t, Academic Fields, Hybrid, Gold) \quad (1)$$

where t is the time of observed variables (t = 2021).

Scopus reports the academic fields for individual journals according to the All Science Journal Classification (ASJC). Based on the ASJC, this study employed variables representing the academic fields of *Agriculture*, *Arts and Humanities*, *Health and*

*Medicine, Social Sciences, Engineering, Natural Sciences, and Computer Science.* Individual journals were assigned to one of these academic fields. The variable *Agriculture* was set to 1 if the journal was in agriculture, and 0 otherwise. The variables that represent other academic fields were defined similarly. As journals in *Arts and Humanities* were the base group when the equation was estimated, this variable did not appear in the APC equation. The variable *Hybrid* was set to 1 if the journal was a hybrid journal, and 0 otherwise. By contrast, the variable *Gold* was set to 1 if the journal was a gold open access journal, and 0 otherwise. The variables representing the academic fields, as well as *Hybrid* and *Gold*, were binary variables, whereas the other variables were natural logarithms. Regarding the independent variables *Download*, *Article*, and *CiteScore*, the interaction terms with the *Hybrid* or *Gold* variable were employed to identify the effect on APCs according to journal type.

(Table I )

### *Data*

Table II presents the summary statistics for the hybrid and gold open access journals used in this study, excluding the binary variables. The mean *APC* for hybrid journals (3,143 USD) was higher than that for gold open access journals (1,688 USD) at the 1% significance level. The same was true for the median *APC*, which for hybrid journals was twice that for gold open access journals. The coefficient of variation of *APC* for hybrid journals was smaller than that for gold open access journals, though recent APCs for hybrid journals varied across journals. Whereas the number of articles (or the number of pages) in a hybrid journal might be restricted due to the production costs of the print version, gold open access journals distributed electronically do not have such restrictions. Nevertheless, Table II shows that hybrid journals tend to publish more articles than gold open access journals, though the number of articles (*Article*) varies across journals. Readers can access all articles in gold open access journals freely. Conversely, many

articles in hybrid journals are closed and require readers to subscribe for access. People can read articles in gold open access journals only by accessing the journal's website, but they can read the articles in hybrid journals in both printed and electronic versions. Therefore, it is hypothesized that the number of downloads for gold open access journals is higher than that for hybrid journals *ceteris paribus*. Although Table II indicates a larger number of downloads for gold open access journals despite the small number of articles, the coefficient of variation was over 100%, which indicated that the number of downloads differed across journals.

Piwowar *et al.* (2018) investigated citation scores for hybrid and gold open access journals published by various publishers and reported that the mean citation score for hybrid journals was larger. Pollock and Michael (2019) concluded that the difference in impact factors between gold open access and other journals became smaller in 2017, as the impact factors for gold open access journals increased significantly. Regarding the Springer imprint journals, the mean (median) *CiteScore* for hybrid journals was the same as that for gold open access journals. The mean *Year* for hybrid journals was larger than that for gold open access journals at the 1% significance level. However, it should be noted that some gold open access journals possess a long history, as they were formerly launched as subscriptions and then converted to open access.

(Table II)

Table III presents the correlation coefficients between variables excluding binary variables. For hybrid journals, all correlation coefficients between *APC* and other variables were significantly positive at the 1% significance level. *Subscription Price* and *APC* exhibited a positive relationship at the 1% significance level, implying that hybrid journals with high subscription prices also tend to have high APCs. All correlation coefficients between *Download* and other variables were positive at the 1% significance level; specifically, the correlation between *Download* and *Article* was positive and relatively large at 0.608, as expected. By contrast, the correlation coefficients between

*Year* and other variables were small.

For gold open access journals, the correlation coefficient between *APC* and *CiteScore* (0.360) was smaller than that for hybrid journals (0.559), whereas the correlation coefficient between *APC* and *Article* (0.279) was higher than that for hybrid journals (0.181). As all articles in gold open access journals are electronically distributed, the correlation coefficient between *Download* and *Article* for gold open access journals (0.766) was larger than that for hybrid journals (0.608). The null hypotheses that the correlation coefficients between *Year* and other variables are equal to 0 were not rejected at the 10% significance level.

(Table III)

Table IV presents the distribution of APCs for hybrid and gold open access journals. Although hybrid journals with APCs between 2,500 USD and 3,000 USD accounted for 49.4% of the total hybrid journals, gold open access journals with APCs between 1,000 USD and 1,500 USD accounted for 39.3%. Table IV shows that the APCs for hybrid journals were significantly higher than those for gold open access journals.

(Table IV)

## 5. Results

Table V presents the estimation results. Although OLS assumes that the variance of each disturbance term is constant, the null hypothesis that it is constant was rejected at the 1% significance level by the White test for heteroskedasticity. Therefore, this study reported heteroskedasticity-consistent standard errors to adjust standard errors. As the number of downloads represents the journal demand from readers, the positive coefficients of *Download* for hybrid and gold open access journals imply that journals with larger demand set higher APCs. However, regarding the number of downloads, the relationship between demand and cost should be discussed. Publishers require computer servers with a large capacity to allow mass access to the websites, leading to increased costs. However,

when the publisher installs servers with a specific capacity, they are utilized across journals, and the costs are shared. Consequently, increased costs per journal caused by enhanced demand are considered small. Therefore, the estimated positive values of *Download* suggest that the Springer imprint sets APCs according to the attention of researchers rather than the cost.

The influence of the number of articles on APCs differed between the two journal types. Table V shows that the estimated coefficient of *Article* for hybrid journals was negative ( $-0.0077$ ), though the value was close to 0. In contrast, Table III shows that the correlation coefficient between *APC* and *Article* for hybrid journals was positive (0.181). However, the partial correlation between *APC* and *Article* for hybrid journals controlling the influence of *Subscription Price* was 0.005, and the null hypothesis that the value is equal to 0 was not rejected at the 10% significance level. Considering the small coefficient of *Article* in equation (1) and the partial correlation, the influence of the number of articles in hybrid journals on APCs was not significant. Conversely, the coefficient of *Article* for gold open access journals was significantly positive (0.0714) at the 5% significance level in Table V, thereby implying that journals with more articles set higher APCs. As high APCs deter authors from submitting their articles, journals that do not attract many submissions might set low APCs.

The coefficients of *CiteScore* for *APC* were positive for both the journal types. The positive influence of *CiteScore* on APCs for gold open access journals was similar to that of Asai (2019; 2020) and Siler and Frenken (2020). The coefficient of *CiteScore* for gold open access journals was larger than that for hybrid journals. This result was similar to that of Schönfelder (2020), who examined journals published by major publishers, although Schönfelder did not use the number of downloads and published articles. In addition to the coefficient of *CiteScore*, this study found that the coefficients of *Download* and *Article* for gold open access journals were larger than those for hybrid journals. Although APCs for hybrid journals have recently varied across journals, Table II shows

that their variance was smaller than that for gold open access journals. Given this result, the Springer imprint might set the APCs for gold open access journals with more sensitivity to journal characteristics than those for hybrid journals.

The coefficient of *Subscription Price* was positive at the 1% significance level, thus implying that hybrid journals with higher subscription prices are associated with higher APCs. As Bosch *et al.* (2020) found that subscription prices tend to increase, there are possibilities of increasing APCs for hybrid journals in the future. The coefficient of *Hybrid* was positive and large at the 1% significance level. The value of *Hybrid* shifted the constant term from 6.3615 to 7.6962, which corresponded to an APC increase of 1,620 USD. Higher APCs for hybrid journals were revealed after controlling for variables representing various characteristics of individual journals. The result was similar to that of Budzinski *et al.* (2020) and Schönfelder (2020). Regarding academic fields, the APCs for social sciences and computer science journals were lower than those for arts and humanities journals (as the baseline). By contrast, journals in agriculture, health and medicine, engineering, and natural sciences tended to set higher APCs. This trend was similar to the findings of previous studies (Crawford, 2020; Solomon and Björk, 2012).

(Table V)

## 6. Discussion

The estimation results found that the Springer imprint set higher APCs for gold open access journals with a greater number of articles. Higher APCs might cause authors to submit their articles to other gold open access journals with lower charges. Hence, the publisher imprint might hesitate to set higher charges for gold open access journals with fewer articles. Using correlation coefficients, Asai (2021) found that whereas Hindawi set higher APCs for gold open access journals with more articles, BMC, a prominent publisher, set higher charges for journals with higher citation scores instead of the number of articles. The positive relationship between the number of articles and APCs for gold

open access journals applied to Hindawi and Springer imprint, but not to that of BMC. Furthermore, Asai (2020) concluded that the APCs for journals published by BMC and Nature Research, which are imprints of Springer Nature, were higher than those by the Springer imprint after controlling for other factors. The findings suggested that Springer Nature merged with prestigious publishers that could set higher APCs for gold open access journals. According to the results of the current study and Asai (2020, 2021), the Springer imprint may not be able to set higher APCs for gold open access journals without being concerned about the number of article submissions.

This study found that after controlling for the influence of other variables, the mean *APC* for hybrid journals was higher than that for gold open access journals by 1,620 USD. However, as APCs cover the production costs of open access articles, it is not reasonable that they differ significantly between the two journal types published by the same publisher imprint. Therefore, the underlying cause of the different APCs must be considered. Most hybrid journals were formerly subscription journals published by leading for-profit publishers, such as Elsevier and Springer Nature. According to Björk (2012), the 3,000 USD that the Springer imprint initially set became the standard for APCs among publishers. For example, although the mean APC applied in 2021 for gold open access journals published by Elsevier was 1,935 USD, the mean APC for hybrid journals was 3,007 USD, based on Elsevier's APC list in 2021. Thus, the fact that APCs for hybrid journals are significantly higher than those for gold open access journals is true of Elsevier.

A difference in APC levels between the two journal types might be caused by a difference in the market structure. In the gold open access journal market, BMC, established in 2000, launched multiple prominent gold open access journals, though the publisher merged with Springer in 2008. PLOS launched a mega journal titled *PLOS ONE*, which set its APC at 1,350 USD in 2006. Several publishers have entered the gold open access journal market since 2000, and their journals have become popular. Accordingly,

leading publishers have launched gold open access journals and have converted several subscription journals to gold open access journals. Leading publishers are thus competing with entrants in the gold open access journal market, which might prompt the Springer imprint to hesitate in setting high APCs (at 3,000 USD) for gold open access journals. By contrast, there are few entrants in the hybrid journal market, except for leading publishers that own many subscription journals. Moreover, leading publishers charge approximately 3,000 USD for open access choice in hybrid journals. Therefore, the Springer imprint and other publishers do not seem to have an incentive to reduce APCs for hybrid journals. In other words, hybrid journals retain the characteristics of subscription journals established by leading publishers. Due to the unavailability of cost data, this study could not determine the price-cost margins for hybrid and gold open access journals. However, no cause for the disparity in APCs, after controlling for journal characteristics, could be found, other than the difference in market structure.

The oligopolistic hybrid journal market may have a negative influence on scholarly communications. This study noted a positive relationship between *APC* for hybrid journals and *Subscription Price*. Several studies found that leading for-profit publishers tended to set higher subscription prices than other publishers (Coomes *et al.*, 2017; Dewatripont *et al.*, 2007; Liu, 2011; Liu and Gee, 2017). As APCs for hybrid journals were initially set according to the average cost of publishing an article (Björk, 2012), excessive subscription journal prices could lead to high APCs. Moreover, the results of this study indicated that increased subscription prices lead to an increase in APCs for hybrid journals. The mean APC that the Springer imprint applied in 2021 (3,143 USD), as displayed in Table II, was higher than the initial APC (3,000 USD), although the variance expanded across hybrid journals.

Higher APCs for hybrid journals could yield two undesirable results. First, if the APCs for hybrid journals exceed the production costs significantly, the revenues from the excessive APCs could be used to reduce those for gold open access journals. Generally,

firms that own both monopolistic and competitive products have an incentive to reduce prices for competitive products using revenues from the monopolistic market to increase their market shares in the competitive market (Waldman and Jensen, 2001). If this aspect is true of open access journals, publishers who own only gold open access journals are disadvantaged when they compete with counterparts who publish both hybrid and gold open access journals. If APCs and subscription revenues for hybrid journals compensate for gold open access journals, such activity might undermine the constructive growth of the open access journal market. Second, according to Larivière *et al.* (2015), leading for-profit publishers with large market shares increased their subscription journal prices, thereby yielding high-profit margins. Similarly, excessive APCs could result in high margins for the publisher, increasing the economic burden on authors, universities, and research funders. Therefore, large-scale publishers that influence scholarly communications significantly should disclose their cost data to demonstrate the rationality of the APC levels. Based on the Directory of Open Access Journals, the Big 5 publishers have recently increased the number of gold open access journal titles, strengthening their presence in the market. If the market power of the Big 5 enhances through mergers and acquisitions with other publishers, the negative influence may extend to not only subscription prices but also APCs for open access journals. Therefore, policymakers need to monitor the hybrid and gold open access journal markets to avoid any anticompetitive activities and consider any plans for merging with other publishers cautiously.

## **7. Conclusion**

There are not many empirical studies that have considered journal characteristics to examine APCs for open access journals. This study estimated APCs for hybrid and gold open access journals in the Springer imprint, and, after controlling for other variables, found that APCs for hybrid journals were significantly higher. Hybrid journals set high

APCs when they were converted from subscription journals, and then maintained the pricing levels. Therefore, it is suggested that the market power of the publisher in the subscription journal market extends to the hybrid journal business. This study also revealed that the factors affecting the APCs differed between the two journal types. For gold open access journals, the number of articles is an important factor in determining the APC level, reflecting the business model that their revenues depend on the APC level and the number of articles. Moreover, the positive relationship between subscription prices and APCs for hybrid journals implies that APCs increase with subscription prices. The market power of leading publishers needs to be monitored continuously.

However, this study could not identify whether the APCs exceeded the production costs significantly because of the unavailability of cost data. Thus, calculating the price-cost margin is necessary to determine the extent of market power. This study examined only open access journals in the Springer imprint. Moreover, the number of gold open access journal titles was small. Therefore, the results cannot be generalized to other publishers of both hybrid and gold open access journals. I will investigate the APC determinants for hybrid and gold open access journals published by Elsevier and Wiley as subsequent studies. Through that investigation, it will be possible to compare the results of Springer imprint in this study with those of other leading publishers. An investigation of other publishers' activities should be conducted to affirm the conclusions of this study.

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### **References**

Asai, S. (2019), "Changes in revenue structure of a leading open access journal publisher:

- the case of BMC”, *Scientometrics*, Vol. 121 No. 1, pp.53–63.  
<https://doi.org/10.1007/s11192-019-03200-1>
- Asai, S. (2020), “Market power of publishers in setting article processing charges for open access journals”, *Scientometrics*, Vol. 123 No. 2, pp.1037–1049.  
<https://doi.org/10.1007/s11192-020-03402-y>
- Asai, S. (2021), “An analysis of revising article processing charges for open access journals between 2018 and 2020”, *Learned Publishing*, Vol. 34 No. 2, pp.137–143.  
<https://doi.org/10.1002/leap.1334>
- Barbers, I., Kalinna, N., and Mittermaier, B. (2018). “Data-driven transition: Joint reporting of subscription expenditure and publication costs”, *Publications*, 6(2).  
<https://doi.10.3390/publications6020019>
- Bergstrom, T. C. (2001), “Free labor for costly journal?”, *Journal of Economic Perspectives*, Vol. 15 No. 3, pp. 183–198. <https://doi.org/10.1257/jep.15.4.183>
- Björk, B.C. (2012), “The hybrid model for open access publication of scholarly articles: a failed experiment?”, *Journal of the American Society for Information Science and Technology*, Vol. 63 No. 8, pp.1496–1504. <https://doi.org/10.1002/asi.22709>
- Björk, B.C. (2017), “Growth of hybrid open access, 2009–2016”, *PeerJ*, Vol. 5, e3878.  
<https://doi.org/10.7717/peerj.3878>
- Björk, B.C. and Solomon, D. (2014), “How research funders can finance APCs in full OA and hybrid journals”, *Learned Publishing*, Vol. 27 No. 2, pp.93–103.  
<https://doi.org/10.1087/20140203>
- Björk, B.C. and Solomon, D. (2015), “Article processing charges in OA journals: relationship between price and quality”, *Scientometrics*, Vol. 103 No. 2, pp.373–385.  
<https://doi.org/10.1007/s11192-015-1556-z>
- Bosch, S., Albee, B. and Romaine, S. (2020), “Costs outstrip library budgets: periodicals price survey”, *Library Journal*, November. Available at  
<https://www.libraryjournal.com/?detailStory=Costs-Outstrip-Library-Budgets->

- Periodicals-Price-Survey-2020# (accessed 20 January 2021).
- Budapest Open Access Initiative (2002, December 14).  
<https://www.budapestopenaccessinitiative.org/read> (accessed 25 December 2020).
- Budzinski, O., Grebel, T., Wolling, J. and Zhang, X. (2020), “Drivers of article processing charges in open access”, *Scientometrics*, Vol. 124 No. 3, pp.2185–2206.  
<https://doi.org/10.1007/s11192-020-03578-3>
- Chressanthis, G.A. and Chressanthis, J.D. (1994), “The determinants of library subscription prices of the top-ranked economics journals: an econometric analysis”, *Journal of Economic Education*, Vol. 25 No. 4, pp.367–382.  
<https://doi.org/10.2307/1182986>
- Coomes, O.T., Moore, T.R. and Breau, S. (2017), “The price of journals in geography”, *The Professional Geographer*, Vol. 69 No. 2, pp.251–262.  
<https://doi.org/10.1080/00330124.2016.1229624>
- Crawford, W. (2020), *Gold open access 2014–2019: articles in journals (GOA5)*, Livermore, California: Cites & Insights Books. <https://waltcrawford.name/goa5.pdf>
- Dewatripont, M., Ginsburgh, V., Legros, P. and Walckiers, A. (2007), “Pricing of scientific journals and market power”, *Journal of the European Economic Association*, Vol. 5 No. 2–3, pp.400–410. <https://doi.org/10.1162/jeea.2007.5.2-3.400>
- Jahn, N. and Tullney, M. (2016), “A study of institutional spending on open access publication fees in Germany”, *PeerJ*, Vol. 4, e2323. <https://doi.org/10.7717/peerj.2323>
- Khoo, S. Y. (2019), “Article processing charge hyperinflation and price insensitivity: an open access sequel to the serials crisis”, *LIBER Quarterly*, Vol. 29 No. 1.  
<https://doi.org/10.18352/lp.10280>
- Kim, S.J. and Park, K.S. (2020), “Market share of the largest publishers in journal citation reports based on journal price and article processing charge”, *Science Editing*, Vol. 7 No. 2, pp. 149–155. <https://doi.org/10.6087/kcse.210>
- Larivière, V., Haustein, S. and Mongeon, P. (2015), “The oligopoly of academic

- publishers in the digital era”, *PLOS ONE*, Vol. 10 No. 6, e0127502.  
<https://doi.org/10.1371/journal.pone.0127502>
- Liu, L.G. (2011), “Economics of scholarly publishing: exploring the causes of subscription price variations of scholarly journals in business subject-specific areas”, *Library Quarterly*, Vol. 81 No. 2, pp.211–232. <https://doi.org/10.1086/658869>
- Liu, L.G. and Gee, H. (2017), “Determining whether commercial publishers overcharge libraries for scholarly journals in the fields of science, technology, and medicine, with a semilogarithmic econometric model”, *Library Quarterly*, Vol. 87 No. 2, pp.150–172. <https://doi.org/10.1086/690736>
- Maddi, A., and Sapinho, D. (2022), “Article processing charges, altmetrics and citation impact: Is there an economic rationale?”, *Scientometrics*,
- Petersen, H.C. (1990), “University libraries and pricing practices by publishers of scholarly journals”, *Research in Higher Education*, Vol. 31 No. 4, pp.307–314. <https://doi.org/10.1007/bf00992268>
- Petersen, H.C. (1992), “The economics of economics journals: a statistical analysis of pricing practices by publishers”, *College & Research Libraries*, Vol. 53 No. 2, pp.176–181. [https://doi.org/10.5860/crl\\_53\\_02\\_176](https://doi.org/10.5860/crl_53_02_176)
- Pinfield, S., Salter, J. and Bath, P. A. (2017), “A “old-centric” implementation of open access: hybrid journals, the “total cost of publication,” and policy development in the UK and beyond”, *Journal of the Association for Information Science and Technology*, Vol. 68 No. 9, pp.2248–2263. <https://doi.org/10.1002/asi.23742>
- Piwowar, H., Priem, J., Larivière, V., Alperin, J.P., Matthias, L., Norlander, B., Farley, A., West, J. and Haustein, S. (2018), “The state of OA: a large-scale analysis of the prevalence and impact of open access articles”, *PeerJ*, Vol. 6, e4375. <https://doi.org/10.7287/peerj.preprints.3119v1>
- Pollock, D. and Michael, A. (2019), “Open access mythbusting: testing two prevailing assumptions about the effects of open access adoption”, *Learned Publishing*, Vol. 32

No. 1, pp.7–12. <https://doi.org/10.1002/leap.1209>

Romeu, C., Gentil-Beccot, A., Kohls, A., Mansuy, A., Mele, S. and Vesper, M. (2014), “The SCOAP3 initiative and the open access article-processing-charge market: global partnership and competition improve value in the dissemination of science”, *CERN-Open-2014-037*. <https://doi.org/10.2314/CERN/C26P.W9DT>, available at <https://cds.cern.ch/record/1735210> (accessed 1 April 2021).

Schönfelder, N. (2020), “Article processing charges: mirroring the citation impact or legacy of the subscription-based model?”, *Quantitative Science Studies*, Vol. 1 No. 1, pp.6–27. [https://doi.org/10.1162/qss\\_a\\_00015](https://doi.org/10.1162/qss_a_00015)

Siler, K. and Frenken, K. (2020), “The pricing of open access journals: diverse niches and sources of value in academic publishing, *Quantitative Science Studies*, Vol. 1 No. 1, pp.28–59. [https://doi.org/10.1162/qss\\_a\\_00016](https://doi.org/10.1162/qss_a_00016)

Solomon, D.J. and Björk, B.C. (2012), “A study of open access journals using article processing charges”, *Journal of the Association for Information Science and Technology*, Vol. 63 No. 8, pp.1485–1495. <https://doi.org/10.1002/asi.22673>

Universities UK (2017, December 5). *Monitoring the transition to open access: December 2017*, available at <https://www.universitiesuk.ac.uk/policy-and-analysis/reports/Pages/monitoring-transition-open-access-2017.aspx> (accessed 6 April 2021)

Waldman, D.E. and Jensen, E.J. (2001). *Industrial Organization: Theory and Practice*. Addison Wesley Longman.

**Table I Definition of Variables**

APC	Article processing charge applied in 2021 (USD)
Download	number of downloads in 2019
Article	number of documents published in 2019
CiteScore	CiteScore in 2019 (in Scopus)
Year	number of years since the journal's inception (2021=1)
Subscription Price	institutional price for the electronic version of a hybrid journal applied in 2021 (USD)
Hybrid	1 if a journal is hybrid, 0 otherwise
Gold	1 if a journal is gold open access, 0 otherwise
Agriculture	1 if a journal is in agriculture, 0 otherwise
Health and Medicine	1 if a journal is in health and medicine, 0 otherwise
Social Sciences	1 if a journal is in social sciences, 0 otherwise
Engineering	1 if a journal is in engineering, 0 otherwise
Natural Sciences	1 if a journal is in natural sciences, 0 otherwise
Computer Science	1 if a journal is in computer science, 0 otherwise

**Table II Summary of Statistics**

	Hybrid Journals (N = 1293)					
	<i>APC</i>	<i>Download</i>	<i>Article</i>	<i>CiteScore</i>	<i>Year</i>	<i>Subscription Price</i>
Mean	3,143***	176,375*	122**	3.6	38***	1,847
Median	3,140***	93,659***	70***	3.2	32***	1,190
SD	428	335,063	177	2.4	26	1,994
CV (%)	14	190	145	68	69	108
	Gold Open Access Journals (N = 61)					
	<i>APC</i>	<i>Download</i>	<i>Article</i>	<i>CiteScore</i>	<i>Year</i>	
Mean	1,688	256,879	65	3.6	15	
Median	1,570	152,632	29	3.2	10	
SD	483	296,377	95	1.8	16	
CV (%)	29	115	145	51	108	

Notes: SD: Standard Deviations CV: Coefficient of Variation

\*\*\*, \*\*, and \* denote the 1%, 5%, and 10% significance levels, respectively.

**Table III Correlation Coefficients**

	Hybrid Journals (N = 1,293)					
	<i>APC</i>	<i>Download</i>	<i>Article</i>	<i>CiteScore</i>	<i>Year</i>	<i>Subscription Price</i>
<i>APC</i>	1.000					
<i>Download</i>	0.257***	1.000				
<i>Article</i>	0.181***	0.608***	1.000			
<i>CiteScore</i>	0.559***	0.346***	0.132***	1.000		
<i>Year</i>	0.132***	0.122***	0.099**	0.032	1.000	
<i>Subscription Price</i>	0.305***	0.390***	0.454***	0.281***	0.338***	1.000
	Gold Open Access Journals (N = 61)					
	<i>APC</i>	<i>Download</i>	<i>Article</i>	<i>CiteScore</i>	<i>Year</i>	
<i>APC</i>	1.000					
<i>Download</i>	0.390***	1.000				
<i>Article</i>	0.279**	0.766***	1.000			
<i>CiteScore</i>	0.360***	0.268**	0.086	1.000		
<i>Year</i>	0.008	0.131	0.071	-0.061	1.000	

Note: \*\*\*, \*\*, and \* denote the 1%, 5%, and 10% significance levels, respectively.

**Table IV Number of Journal Titles by APC**

	Hybrid	Gold
$0 < \text{APC} \leq 1,000$	0	3
$1,000 < \text{APC} \leq 1,500$	0	24
$1,500 < \text{APC} \leq 2,000$	0	21
$2,000 < \text{APC} \leq 2,500$	0	8
$2,500 < \text{APC} \leq 3,000$	639	5
$3,000 < \text{APC} \leq 3,500$	422	0
$3,500 < \text{APC} \leq 4,000$	211	0
$4,000 < \text{APC} \leq 4,500$	21	0

**Table V Estimation Results**

	Coefficient
Constant	6.3615 (0.3851)***
$\ln \text{Download} \times \text{Hybrid}$	0.0174 (0.0042)***
$\ln \text{Download} \times \text{Gold}$	0.0524 (0.0398)
$\ln \text{Article} \times \text{Hybrid}$	-0.0077 (0.0041)*
$\ln \text{Article} \times \text{Gold}$	0.0714 (0.0312)**
$\ln \text{CiteScore} \times \text{Hybrid}$	0.0545 (0.0059)***
$\ln \text{CiteScore} \times \text{Gold}$	0.1125 (0.0514)**
$\ln \text{Year}$	-0.0034 (0.0047)
$\ln \text{Subscription Price}$	0.0114 (0.0044)***
<i>Hybrid</i>	1.3347 (0.3860)***
<i>Agriculture</i>	0.0762 (0.0134)***
<i>Health and Medicine</i>	0.1552 (0.0116)***
<i>Social Sciences</i>	-0.0237 (0.0103)**
<i>Engineering</i>	0.0305 (0.0124)**
<i>Natural Sciences</i>	0.0280 (0.0116)**
<i>Computer Science</i>	-0.0428 (0.0128)***
Adjusted R <sup>2</sup>	0.7680

Notes:  $\ln$  indicates natural logarithm.

Heteroskedasticity-consistent standard errors are in parentheses.

\*\*\*, \*\*, and \* denote the 1%, 5%, and 10% significance levels, respectively.