Day of the week submission effect for accepted papers in Physica A, PLOS ONE, Nature and Cell

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Abstract
The particular day of the week when an event occurs seems to have unexpected consequences. For example, the day of the week when a paper is submitted to a peer reviewed journal correlates with whether that paper is accepted. Using an econometric analysis (a mix of log–log and semi-log based on undated and panel structured data) we find that more papers are submitted to certain peer review journals on particular weekdays than others, with fewer papers being submitted on weekends. Seasonal effects, geographical information as well as potential changes over time are examined. This finding rests on a large (178,000) and reliable sample; the journals polled are broadly recognized (Nature, Cell, PLOS ONE and Physica A). Day of the week effect in the submission of accepted papers should be of interest to many researchers, editors and publishers, and perhaps also to managers and psychologists.

Keywords Day of the week effect · DWE · Peer reviewed journals · Seasonal effects · GIS

Introduction
In most of the world, weekends are set apart from weekdays. This delineation is a social convention and at first glance nothing seems to distinguish one day from another. However, Rossi and Rossi (1977) found that positive moods are more likely to occur at weekends. French (1980) found that Monday stock returns tends to be negative while returns on Tuesday, Wednesday, Thursday and Friday tend to be positive. Chang et al. (1993), Berument and Kiymaz (2001), Bhattacharya et al. (2003), Fidrmuc and Tena (2015), Dhesi et al. (2016) have also studied the DWE in the context of different financial

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settings. More recently DWE’s have been identified in other areas such as ecology (Marr and Harley 2002), medicine (Bell and Redelmeier 2001), demography (Herteliu et al. 2015), meteorology (Dessens et al. 2001), risk calculations (Doherty et al. 1998) and scientometrics (Cabanac and Hartley 2013; Campos-Arceiz et al. 2013; Hartley and Cabanac 2017; Ausloos et al. 2016, 2017).

Recently Cabanac and Hartley (2013) studied acceptance of technical manuscripts to journals and found big differences between week–day and weekend submissions. They found that submissions are at a maximum on Mondays. Hartley and Cabanac (2017) confirmed this result and also noticed that submissions are at a minimum on weekends. Ausloos et al. (2016) found that papers submitted on either Tuesdays or Wednesdays were more likely to be accepted for publication than papers submitted on weekends. Other reports (Shalvi et al. 2010; Bornmann and Daniel 2011; Schreiber 2012) observed a seasonal effect—the so-called “seasonal overloading of editorial desks”—for decisions made during peer review process.

Here using a large data set of papers published in academic journals, we confirm a DWE for the submission day of accepted papers, however seasonal or geographical signals are less noticeable. Papers submitted on Tuesdays are more likely to be accepted by Physica A and Nature whereas Wednesdays seem the most likely day to submit and secure acceptance to PLOS ONE. For Cell Mondays and Tuesdays seem the best submission days in case of accepted papers. Relative to previous researches, we introduce methodological improvements (meta-data scraper). Even where we confirm conclusions from previous studies, we rely on different econometric models (mix of log–log and semi-log based on undated and panel structured data) and visual elements (localization quotients).

Materials and methods

Data collection process

The core data upon which the current paper relies is wholly public. Our approach is similar to that of Cabanac and Hartley (2013). Even journals that hide papers behind a paywall freely offer (1) abstracts, (2) authors’ information and (3) a brief history of peer review process on their web sites. Using a tailor-made web scraper we extracted information from the following journals: Nature, Cell, PLOS ONE and Physica A: Statistical Mechanics and its Applications. The date when a manuscript is received by the journal’s system is provided by metadata and is labelled in similar manner: Nature uses “date received” while Cell, PLOS ONE and Physica A use “received”. If a first parsing of a paper’s information failed to retrieve the required data, the algorithm tried to parse again. In this way, we generated a large number of inquiries. Sometimes a publisher’s server banned our web scraper for several days. For this reason, the retrieved information is not exhaustive. Nevertheless, we recovered significant totals of the available data (Physica A: 83.4%; PLOS ONE: 99.9%; Nature: 76.4% and Cell: 68.7%) in our target journals (as may be seen in the Table 1) and believe it is representative of the total. Moreover, since only electronic submissions offer precise information we collected data only for submissions after 2000.

Papers that apparently did not pass a peer review process (editors’ lists, editorials, corrigenda, errata, etc.) signaled by no date for reception of either an initial or revised submission were removed from the data set.

We gathered dates of accepted papers’ submission using a Web scraper (Kobayashi and Takeda 2000) developed to automatically search and retrieve needed information on the
The software application was developed by the authors using a Java platform. For parsing Web page content and extracting searched information we used the open-source Jsoup library (WWW3). Retrieved data was stored in a MySQL database (WWW4). The Web scraper executed recursively the following sequence of steps for each analyzed journal:

1. The process starts with the journal Web page that contains web archive information for each issue. Starting from this page the scraper was able to extract the web link for each issue. Each link was recorded, to avoid reaching the same link in future searches, and it was accessed, to process each issue’s Web page;

2. From each issue’s Web page, recorded in the previous step, we extracted information for each article: title, authors, pages (if available) and their Web pages links for further processing. The sequence that searched for articles was implemented by a prior analysis Web page structure. For example, each online issue of the PLOS ONE journal defined the articles using a list of div HTML tags, each having the “article-block” class:

   ```html
   <div class="articles-list cf" data-subst="article-list">
     <div class="article-block">
       <a class="article-url" href="/plosone/article?id=10.1371%2fjournal.pone.0156445">
         <img class="grayscale" src="">
       </a>
       <div class="details">
         <!--article page Web link -->
         <!--article title -->
         <!--article authors -->
       </div>
     </div>
   </div>
   <!--next article block -->
   ```

3. Each article’s Web page was accessed and analyzed in order to get submission date, accepted date and publication date. As for the journal issue Web page, a prior analysis
of the article Web page structure has been done in order to write the code sequence that will find and retrieve the article’s bibliographic information.

Given the restricted number of analyzed journals it was more efficient to define a search and retrieval pattern particular to each journal’s website internal structure.

For all analyzed journals, the recorded information was retrieved from their public pages. Because a Web scraper is capable of requesting Web pages at a much higher rate than a human user, special care was taken not to disrupt or affect the Web server functionality, e.g., by pausing the scraper process for several seconds after parsing each issue page. The scraper script and its technicalities are available in Supplementary Information section.

The first journal where our scraper attempted to get the information was Physica A. During 29–30 April 2016 period, we collected more than 9000 papers. On the second day of inquiries, Elsevier banned access to its computer which meant that all journals included in Science Direct (not just Physica A) were inaccessible. Starting with 29th April 2016 till 22nd May 2016, our scraper got data (almost 149 000 papers) from PLOS ONE journal. Within first 10 days of May 2016 our scraper got more than 4 500 papers from Nature. We took into consideration only research papers (labeled as letters or articles). Because the format of Nature’s website changed in 2010, no information was retrieved from Nature prior to 2010. Between 22nd May 2016 and 26th May 2016, our scraper investigated Cell website and retrieved information for papers published between 2003 and 2016. Prior to 2003 there was no information about date when a manuscript was accepted/published. Thus, we included within our dataset more than 4000 papers from Cell. Between January and April 2017, during the second data collection process, information regarding corresponding authors’ affiliation country has been appended to the initial database.

Even if the day of submission can be determined, there is a potential bias induced by the server location (e.g. a paper submitted from Europe at 1:00 GMT is registered on the previous day if the server location is in USA). We were unable to resolve this issue since the hour of submission is unavailable. In our opinion, this is not an important constraint on the findings, because we have so much data. Another potential bias could occur if the online manuscripts submission systems (portals) do not provide accurate meta data (due to internal procedures required) regarding the submission date. In line with Cabanac and Hartley (2013), the editorial offices of the four journals which our dataset rely on were approached by email with the following question:

[...] may I ask you if there is any delay/bias from the moment which a co-author hits “submit” button and the one (calendar date) which is registered in your system as submitted date?

All four editorial offices confirmed to us that there is no such bias in their processes. One could claim that since Nature employs full-time editors, whom typically do not work on weekends, their metadata is special. Therefore, we provide below the clarification message received from Nature’s editorial office (Teresa Dudley) regarding this issue:

1 Scraper worked on the following address: http://www.sciencedirect.com/science/journal/03784371/.
2 Scraper worked on the following address: http://journals.plos.org/plosone/browse/ while for the second round of data collection an archive (available on: https://www.dropbox.com/s/n6ldppdrqgj1xoyo/All%20of%20PLOS.tgz?dl=0) with metadata information regarding PLOS ONE’s papers was used.
3 Scraper worked on the following address: http://www.nature.com/nature/archive/index.html.
4 Scraper worked on the following address: http://www.cell.com/.
At Nature, the submission date that appears on the published paper is the date of submission of the version that received a decision to revise and resubmit, in other words a positive decision. In some cases, authors whose paper was rejected without a request to revise after peer review may return to the journal much later with a substantially revised manuscript; if this manuscript is eventually published, the submission date on the published paper will be that of the later submission.

**Recorded variables**

For each paper which passed a peer review process several variables were recorded: (1) journal; (2) title; (3) volume; (4) author(s); (5) initial reception date; (6) revised version reception date—if any; (7) acceptance date—if any; (8) online availability date—if any and (9) number of pages—if available. Numerical values were assigned as follows: (10) number of pages—if available; (11) number of authors; (12) week–day of initial submission (1 for Monday, 2 for Tuesday, 3 for Wednesday, 4 for Thursday, 5 for Friday, 6 for Saturday and 7 for Sunday); (13) week–day of revised version (same codification like for variable xii); (14) week of initial submission (a number between 1 and 53); (15) year of initial submission; (16) year of publication/acceptance. In a second round of data collection, information regarding (17) corresponding authors’ affiliation country is recorded. For few thousand papers, the process of choosing affiliation country has been performed manually. Around a few hundred papers for which affiliation country was not clear enough (e.g. multiple corresponding authors from multiple countries, international organizations with no clear affiliation country, not enough data etc.) have been withdrawn from the database.

**The dependent variable**

For each journal distribution of papers by day of the week was tested (via Chi Square) against uniformity. The critical value for a significance level 0.05 and 6 degrees of freedom is 12.59. The same approach was conducted for the consolidated dataset. In addition the same procedure was applied if considering only week–days. The critical value being in this case 9.49 (for a significance level of 0.05 and 4 degrees of freedom).

Furthermore, in order to test the sensitivity of deviations from uniformity, a regression model was designed. The time span for rolling over the calendar is the week. For each week and for each journal the following sequence was computed:

$$\text{UD}_{ij} = N_{ij}/7 = \frac{\sum_{k=1}^{7} n_{kij}}{7} = \frac{1}{7} \sum_{k=1}^{7} \sum_{a=1}^{p} a_{kij}$$  \hspace{1cm} (1)$$

where \(\text{UD}_{ij}\) denotes the uniform distribution of papers per day submitted during week \(i\) to journal \(j\), \(N_{ij}\) is the total number of papers received during week \(i\) by journal \(j\) and \(n_{kij}\) is the number of papers submitted in the \(k\)th day of the week starting from Monday (1) to Sunday (7), in the week, \(i\), of the year, for a particular journal \(j\).

Particularly \(a\) is the lowest unit recorded, the article and it is referred by the day of the week of submission \((k)\), week of the year \((i)\) and journal where it was submitted \((j)\). In a given day, \(k\) from week \(i\), journal \(j\) we have 0 to maximum \(p\) articles submitted.

In this context, ratio to uniform distribution (RUD) for a specific day \(k\), of the week \(i\) for journal \(j\) is defined as follows:
\[ RUD_{ij} = \frac{\prod_{k=1}^{7} n_{kij}}{UD_{ij}} \]  

(2.1)

N.B. For “a” articles submitted in the same day of the week\( (k) \), in the same week\( (i) \) of the year we have the same RUD.

For the consolidated data set of the journals, we have:

\[ RUD_{ki} = \frac{1}{N_i} \sum_{j=1}^{p} \sum_{k=1}^{7} n_{kij} \]

\[ UD_i, \] 

(2.2)

where \( p = 4 \), represents the number of journal taken into consideration.

In order to be clearer how the dependent variable is computed, an extract from the database of 47 PLOS ONE papers received in 14 weeks is presented in Table 2. The step by step computation details are also available in Table 2. The reception flow is quite diverse: there are weeks with one, two, three or four received papers, but there is one with 26. The daily flows are diverse too; most of the days show only one incoming paper but there is an exceptional one (7th August, 2006) with 16.

Furthermore, a look on the dependent variable is important. This variable should be inserted as the dependent variable within the regression models. In order to do so, a preliminary inspection of its distribution (within each individual journal and also to the consolidated dataset) is necessarily. In order to use “Ordinarily Least Squares” (OLS) regression parameter estimations at least a normal distribution is expected for the dependent variable. A classical test—Jarque–Bera (JB)—for normality is used (Table 3).

The potential dependent variable—RUD—does not follow normal distribution, no matter which dataset is considered. The most common way to adapt a non-Gaussian distribution for a potential use within the regression models is the log transformation (Table 4).

The log transformation helps and the computed values for JB test became three digits for Physica A and Nature or even better—two digits—for Cell while within the consolidated dataset and PLOS ONE there are six digits figures. Two steps classical transformation (Linnet 1987) are used. First one aims to avoid skewness while the second one tries to avoid kurtosis. Various parameters are tested for each dataset and those which minimize the JB test are kept (Table 5).

After the transformations, the computed JB test for each sample looks much better even if the null hypothesis (Gaussian distribution) is still rejected. For Physica A, Nature and Cell the outcomes are small (two digits not far away from the critical value) while for PLOS ONE and the consolidated dataset there are three digits level records. A visual inspection (Fig. 1) of these distributions shows that there are plenty of outliers.

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5 For each dataset, there are two hypothesis: \( H_0: \) normal (Gaussian) distribution and \( H_1: \) the distribution is not a normal one. The statistic test is computed by: \( JB = N(\frac{\text{Skewness}^2}{6} + \frac{\text{Kurtosis}^2}{24}) \) where \( N \) is number of cases and skewness and kurtosis are measured basically by Pearson’s moment coefficients. This test follows a Chi square distribution with two degrees of freedom (most common critical value is: \( \chi^2_{0.05,2} = 5.99 \)). A detailed presentation about formula used for Kurtosis and its components is available within supplementary information (SI_ Kurtosis.docx).
### Table 2: Database extract and step by step computation for the dependent variable RUD$_{kij}$

| ID   | Received date (a) | Weekday (k = 1 = Monday to 7 = Sunday) | Received Week(i) | UD$_{ij}$ | RUD$_{kij}$ |
|------|-------------------|----------------------------------------|------------------|----------|-------------|
| 167044| 09-12-05          | 5                                      | 50               | 1/7 = 0.142857 | 1/0.14 = 7  |
| 167045| 13-02-06          | 1                                      | 7                | 4/7 = 0.571429 | 1/0.57 = 1.75 |
| 167046| 14-02-06          | 2                                      | 7                | 4/7 = 0.571429 | 2/0.57 = 3.5  |
| 167047| 14-02-06          | 2                                      | 7                | 4/7 = 0.571429 | 2/0.57 = 3.5  |
| 167043| 17-02-06          | 5                                      | 7                | 4/7 = 0.571429 | 1/0.57 = 1.75 |
| 167042| 08-03-06          | 3                                      | 10               | 1/7 = 0.142857 | 1/0.14 = 7  |
| 167041| 16-03-06          | 4                                      | 11               | 1/7 = 0.142857 | 1/0.14 = 7  |
| 167040| 27-03-06          | 1                                      | 13               | 3/7 = 0.428571 | 1/0.43 = 2.33333 |
| 167033| 28-03-06          | 2                                      | 13               | 3/7 = 0.428571 | 1/0.43 = 2.33333 |
| 166855| 29-03-06          | 3                                      | 13               | 3/7 = 0.428571 | 1/0.43 = 2.33333 |
| 167038| 06-04-06          | 4                                      | 14               | 1/7 = 0.142857 | 1/0.14 = 7  |
| 166926| 09-05-06          | 2                                      | 19               | 2/7 = 0.285714 | 1/0.29 = 3.5  |
| 166885| 11-05-06          | 4                                      | 19               | 2/7 = 0.285714 | 1/0.29 = 3.5  |
| 167034| 16-05-06          | 2                                      | 20               | 2/7 = 0.285714 | 1/0.29 = 3.5  |
| 166750| 18-05-06          | 4                                      | 20               | 2/7 = 0.285714 | 1/0.29 = 3.5  |
| 167037| 02-06-06          | 5                                      | 22               | 2/7 = 0.285714 | 2/0.29 = 7  |
| 167039| 02-06-06          | 5                                      | 22               | 2/7 = 0.285714 | 2/0.29 = 7  |
| 167036| 19-06-06          | 1                                      | 25               | 1/7 = 0.142857 | 1/0.14 = 7  |
| 167032| 30-06-06          | 5                                      | 26               | 1/7 = 0.142857 | 1/0.14 = 7  |
| 166830| 26-07-06          | 3                                      | 30               | 1/7 = 0.142857 | 1/0.14 = 7  |
| 167029| 01-08-06          | 2                                      | 31               | 1/7 = 0.142857 | 1/0.14 = 7  |
| 138586| 07-08-06          | 1                                      | 32               | 26/7 = 3.714286 | 16/3.71 = 4.30769 |
| 166695| 07-08-06          | 1                                      | 32               | 26/7 = 3.714286 | 16/3.71 = 4.30769 |
| 166757| 07-08-06          | 1                                      | 32               | 26/7 = 3.714286 | 16/3.71 = 4.30769 |
| 166870| 07-08-06          | 1                                      | 32               | 26/7 = 3.714286 | 16/3.71 = 4.30769 |
| 166937| 07-08-06          | 1                                      | 32               | 26/7 = 3.714286 | 16/3.71 = 4.30769 |
| 166954| 07-08-06          | 1                                      | 32               | 26/7 = 3.714286 | 16/3.71 = 4.30769 |
| 166957| 07-08-06          | 1                                      | 32               | 26/7 = 3.714286 | 16/3.71 = 4.30769 |
| 166963| 07-08-06          | 1                                      | 32               | 26/7 = 3.714286 | 16/3.71 = 4.30769 |
| 166970| 07-08-06          | 1                                      | 32               | 26/7 = 3.714286 | 16/3.71 = 4.30769 |
| 166988| 07-08-06          | 1                                      | 32               | 26/7 = 3.714286 | 16/3.71 = 4.30769 |
| 166992| 07-08-06          | 1                                      | 32               | 26/7 = 3.714286 | 16/3.71 = 4.30769 |
| 166996| 07-08-06          | 1                                      | 32               | 26/7 = 3.714286 | 16/3.71 = 4.30769 |
| 167018| 07-08-06          | 1                                      | 32               | 26/7 = 3.714286 | 16/3.71 = 4.30769 |
| 167022| 07-08-06          | 1                                      | 32               | 26/7 = 3.714286 | 16/3.71 = 4.30769 |
| 167024| 07-08-06          | 1                                      | 32               | 26/7 = 3.714286 | 16/3.71 = 4.30769 |
| 167030| 07-08-06          | 1                                      | 32               | 26/7 = 3.714286 | 16/3.71 = 4.30769 |
| 166749| 08-08-06          | 2                                      | 32               | 26/7 = 3.714286 | 5/3.71 = 1.34615 |
| 166922| 08-08-06          | 2                                      | 32               | 26/7 = 3.714286 | 5/3.71 = 1.34615 |
| 167004| 08-08-06          | 2                                      | 32               | 26/7 = 3.714286 | 5/3.71 = 1.34615 |
| 167009| 08-08-06          | 2                                      | 32               | 26/7 = 3.714286 | 5/3.71 = 1.34615 |
| 167031| 08-08-06          | 2                                      | 32               | 26/7 = 3.714286 | 5/3.71 = 1.34615 |
The regression models

**Article unit model with week–day component**

This model is a linear one:

\[ y_{akij} = \beta_0 + \beta_1 \text{MON}_{aij} + \beta_2 \text{TUE}_{aij} + \beta_3 \text{WED}_{aij} + \beta_4 \text{THU}_{aij} + \beta_6 \sum_{k=6}^{7} \text{WEEKEND}_{aij} + \epsilon_{aij} \]  

(3)

where \( \beta_0 \) to \( \beta_6 \) are regression parameters to be estimated. In this kind of model \( a \) is the index for a certain article received in the day \( k \), week \( i \) for journal \( j \), as defined above at (1).

It worth to underline that day of the week dummy from (3) will vary only by index \( k \).

MON, TUE, WED, and THU are dummy variables (1 if paper was submitted in a Monday or Tuesday or Wednesday or Thursday and 0 otherwise). WEEKEND is also a dummy variable (generally, 1 if paper was submitted in a Saturday or in a Sunday and 0 otherwise).
| Dataset (sample) | First step transformation | Second step transformation | Skewness | Kurtosis | Cases (N) | Jarque–Bera test |
|------------------|---------------------------|----------------------------|----------|----------|-----------|-----------------|
| Physica A        | $y_{PA} = \log_{10} \text{RUD} - 0.06$ | $y_{PA}^* = \left( y_{PA} + 1 \right)^{1.82} - 1 / 1.82$ | 0.056    | -0.135   | 9825      | 12.60           |
| PLOS ONE         | $y_{PO} = \left[ \left( \text{RUD} \right)^{0.1} - 1 \right] / 6$ | $y_{PO}^* = \left( y_{PO} + 1 \right)^{-0.8} - 1 / -0.8$ | 0.129    | -0.094   | 160,172    | 503.21          |
| Nature           | $y_{NT} = \log_{10} \text{RUD} + 0.05$ | $y_{NT}^* = \left( y_{NT} + 1 \right)^{0.8} - 1 / 0.8$ | -0.065   | 0.224    | 4653       | 13.00           |
| Cell             | $y_{CL} = \log_{10} \text{RUD} - 0.05$ | $y_{CL}^* = \left( y_{CL} + 1 \right)^{1.15} - 1 / 1.15$ | 0        | -0.386   | 3777       | 23.45           |
| Consolidated     | $y_{CT} = \left[ \left( \text{RUD} \right)^{4} - 1 \right] / 4$ | $y_{CT}^* = \left( y_{CT} + 1 \right)^{-0.954} - 1 / -0.954$ | -0.067   | 0.302    | 178,427     | 811.55          |
Fig. 1  Distributions of dependent variable by intervals
otherwise). However, a subtle approach, introduced recently (Campos-Arceiz et al. 2013), is used for manuscripts originating from almost two dozen of Countries having Special Weekends (SWC). It is about: Afghanistan, Algeria, Bahrain, Bangladesh, Brunei, Egypt, Hong-Kong, Iraq, Israel, Jordan, Kuwait, Libya, Mauritania, Nepal, Oman, Qatar, Saudi Arabia, Sudan, Syria, United Arab Emirates, and Yemen. Most common weekend type for this SWC is, currently, Friday and Saturday. It was also taken into account the changing of the weekend rules over time (2006–2009) as has been detailed by Campos-Arceiz et al. (2013). FRIDAY is considered to be the reference point. ε denoting the “perturbation” (here as well as in the next models), due to other factors, is assumed to be a white noise as usual in such regression model schemes.

**Article unit model with seasonal component**

In order to test other reported (Shalvi et al. 2010; Bornmann and Daniel 2011; Schreiber 2012) seasonal effects, three dummy variables are used (1 if paper was submitted within a season and 0 otherwise). Classic definition of seasons, as Hartley (2011) suggests, is used: SPRING (March to May), SUMMER (June to August), FALL (September to November) and WINTER (December to February).

\[
y_{akij}^* = \beta_0 + \beta_1 \text{SPRING}_{akij} + \beta_2 \text{SUMMER}_{akij} + \beta_3 \text{FALL}_{akij} + \varepsilon_{akij}
\]

WINTER is considered to be the reference point and, the indexes \(a, k, i, j\) have the same significance as in Eq. (3).

Here we note that season dummies from (4) will vary only by index \(i\), according to the position of the week, \(i\) 1 to 52 in one season or another.

**Article unit model with geographic component**

Geographical data (corresponding authors’ affiliation country) is included in this model using four dummy variables (1 if the paper is originated within a specific continent and 0 otherwise): AFRICA, AMERICA, ASIA, and OCEANIA.

\[
y_{akij}^* = \beta_0 + \beta_1 \text{AMERICA}_{akij} + \beta_2 \text{AFRICA}_{akij} + \beta_3 \text{ASIA}_{akij} + \beta_4 \text{OCEANIA}_{akij} + \varepsilon_{akij}
\]

EUROPE is considered to be the reference point, the indexes \(a, k, i, j\) have the same significance as in Eq. (3).

Here the geographic component from (5) will vary only by index \(a\), since this variable is associated with the author of a certain article: \(a\).

**Control variables and subsequent models**

We are aware that there are plenty of factors which can influence our dependent variable. Previous research demonstrates that the scientific production, in general, can be affected by various factors: country size (Lippi and Mattiuzzi 2017); economic level (Bernardes and Albuquerque 2003; Lippi and Mattiuzzi 2017); level of funding and/or science policy (Henriques and Laredo 2013; Crespi and Geuna 2008; Ebadi and Schiffauerova 2016); team size (Ebadi and Schiffauerova 2016); non-economic factors (Inönü 2003). We select from this list two factors which can affect scientific papers’ production (and flows): HDI
(the numeric figure for each country regarding Human Development Index as a proxy for the economic (lack) of development and AUTHORS which denotes the number of authors for the paper j. In case of the AUTHORS, it is expected that an increase in team size also increases the chance that a co-author who does not work (no matter what kind of activity: manuscript design, preparation for submission, agreement on the final form etc.) outside of the regular program (e.g. during the weekends). Subsequently, this control factor should be positively correlated to the dependent variable.

Furthermore, since the current paper is related in a great extent to the timing, we are identifying a very easy to measure important period of time which may interfere on leisure/working time: CHRISTMAS is a dummy variable (1 if paper was submitted between 20th of December and 10th of January and 0 otherwise). When is about leisure/working time balance, an interesting idea was coined by Hofstede et al. (2010:251). Here they explain what are the differences between Short Term (STO) and Long Term Oriented (LTO) countries. They state that for LTO countries “leisure time is not important” while for STO countries “leisure time is important”. Therefore, in our case is expected that countries with a higher LTO index to work harder during the weeks-ends. Hence, we take exact figures about LTO for 93 countries (Hofstede et al. 2010:255–258) and insert this variable within the models.

Based on this the following general multiple regression models are designed:

\[
y_{akij}^{**} = \beta_0 + \beta_1 \text{MON}_{akij} + \beta_2 \text{TUE}_{akij} + \beta_3 \text{WED}_{akij} + \beta_4 \text{THU}_{akij} + \beta_5 \text{WEEKEND}_{akij} + \beta_6 \text{SPRING}_{akij} + \beta_7 \text{SUMMER}_{akij} + \beta_8 \text{FALL}_{akij} + \varepsilon_{akij} \tag{6}
\]

\[
y_{akij}^{**} = \beta_0 + \beta_1 \text{MON}_{akij} + \beta_2 \text{TUE}_{akij} + \beta_3 \text{WED}_{akij} + \beta_4 \text{THU}_{akij} + \beta_5 \text{WEEKEND}_{akij} + \beta_6 \text{SPRING}_{akij} + \beta_7 \text{SUMMER}_{akij} + \beta_8 \text{FALL}_{akij} + \beta_9 \text{AMERICA}_{akij} + \beta_{10} \text{AFRICA}_{akij} + \beta_{11} \text{ASIA}_{akij} + \beta_{12} \text{OCEANIA}_{akij} + \varepsilon_{akij} \tag{7}
\]

\[
y_{akij}^{**} = \beta_0 + \beta_1 \text{MON}_{akij} + \beta_2 \text{TUE}_{akij} + \beta_3 \text{WED}_{akij} + \beta_4 \text{THU}_{akij} + \beta_5 \text{WEEKEND}_{akij} + \beta_6 \text{SPRING}_{akij} + \beta_7 \text{SUMMER}_{akij} + \beta_8 \text{FALL}_{akij} + \beta_9 \text{AMERICA}_{akij} + \beta_{10} \text{AFRICA}_{akij} + \beta_{11} \text{ASIA}_{akij} + \beta_{12} \text{OCEANIA}_{akij} + \beta_{13} \text{CHRISTMAS}_{akij} + \varepsilon_{akij} \tag{8}
\]

\[
y_{akij}^{**} = \beta_0 + \beta_1 \text{MON}_{akij} + \beta_2 \text{TUE}_{akij} + \beta_3 \text{WED}_{akij} + \beta_4 \text{THU}_{akij} + \beta_5 \text{WEEKEND}_{akij} + \beta_6 \text{SPRING}_{akij} + \beta_7 \text{SUMMER}_{akij} + \beta_8 \text{FALL}_{akij} + \beta_9 \text{AMERICA}_{akij} + \beta_{10} \text{AFRICA}_{akij} + \beta_{11} \text{ASIA}_{akij} + \beta_{12} \text{OCEANIA}_{akij} + \beta_{13} \text{CHRISTMAS}_{akij} + \beta_{14} \log_{10} \text{AUTHORS}_{akij} + \varepsilon_{akij} \tag{9}
\]

\[\text{Data for HDI2016 is available on: http://hdr.undp.org/en/data. It is known that HDI is a geometric mean of three normalized indices (health, education, and income).}\]
The meaning of the indexes \(a, k, i, j\), are the same as in (3), underlining that the AUTHORS, HDI and LTO will vary only by index \(a\), CHRISTMAS by particular cases of index \(i\).

When the consolidated dataset is considered, the models are the same, the only thing which differs from the models 6–11 is the computations of the dependent variable, \(y\). In this case based on the relation (2.2) and the applied transformation the variable will be \(y^{**}\).

The approach for the model design is from simple to complex adding, step by step, specific factors. Hence, at first step (6) the days of the week are combined with seasons while at the second step (7) continents are added. Furthermore, one by one the control factors are inserted: CHRISTMAS (8), AUTHORS (9), HDI (10) and LTO (11).

In order to check potential behavior changes over the time, the dataset is also analyzed in a longitudinal way. The covered timespan is split in five roll windows as follows: [2000–2004], [2005–2007], [2008–2010], [2011–2013], and [2014–2016]. The models (3)–(11) are run on every roll window. The same procedure is followed when data set relies only on the individual journals (Nature, Cell, Physica A and PLOS ONE).

The regression models were validated via classical tests for: (i) model itself, (ii) estimated parameters (iii) residuals and (iv) multicollinearity. For all tests, the maximum significance level was set to be equal to 0.1.

The panel regression

We define a particular structure of panel as follows: the time component is given by \(T = 2435\) consecutive days from 01.01.2010 to 31.08.2016 and the cross-section is represented by top \(N = 11\) countries. Now the characteristics are referred a cell of type \((c, t)\), the \(c\) being the index for countries and \(t\) for the time(day). The RUD\(_{kij}\) defined in (2.1. and 2.2.) becomes RUD\(_{ct}\), the variation of day of the week \(k\) in the week \(i\) is now contained in \(c\) index.

With the experience of previous models, in line with (Orazbayev 2017), a test and a control for other factors is performed. The following model is used:
\[ \log_{10} RUD_{ct} = \beta_0 + \beta_1 \text{MON}_{ct} + \beta_2 \text{TUE}_{ct} + \beta_3 \text{WED}_{ct} + \beta_4 \text{THU}_{ct} + \beta_5 \text{WEEKEND}_{ct} + \beta_6 \log_{10} \text{AUTHORS}_{ct} + \beta_7 \text{CHRISTMAS}_{ct} + \beta_8 \text{FALL}_{ct} + \beta_9 \text{SUMMER}_{ct} + \beta_{10} \text{SPRING}_{ct} + \beta_{11} \log_{10} \text{HDI}_{cj} + \beta_{12} \log_{10} \text{LTO}_{cj} + \beta_{13} \log_{10} t + u_c + \lambda_{ct} \]

(12)

In order to keep a relevant daily granularity, we remove some parts of the dataset. First, from the available set of countries, only the top 11 countries were chosen for which total number of papers is more than 77% out of the total papers. The rest of 23% dataset was formed by countries which have a very small number of articles. Second, in the beginning of the period (2000–2009) in most of the days, the number of submitted papers was zero. Therefore a minimal daily granularity was not possible for this specific timespan. Hence, after timespan reduction as well as countries’ removal, the dataset used for panel regression records 120,258 papers representing more than two thirds out of the initial 178,427 papers, accumulated in a \( N \times T = 26,785 \) panel cells as defined above in this sub-section.

In (12) the dependent variable is transformed:

\[ \log_{10} \text{RUD}_{ct} = \frac{1}{p} \sum_{a=1}^{p} \log_{10} \text{RUD}_{act} \]

(13)

where \( p \) is the number of articles published in the day \( t \) from country \( c \).

The HDI and LTO are covariates specific to a country \( j \). They were considered as fixed in time. The number of authors is also calculated as a mean, since in a specific day \( t \) as there are more articles with different number of authors.

Hence

\[ \log_{10} \text{AUTHORS}_{ct} = \frac{1}{p} \sum_{a=1}^{p} \log_{10} \text{AUTHORS}_{act} \]

(14)

In (12) the \( u_c \) is the cross-sectional random component which measures the impact of other unknown factors associated with the results.

\[ \varepsilon_{ct} = u_c + \lambda_{ct} \]

(15)

denotes the total perturbation component.

Moreover, in particular cases, we have multiple articles from country \( j \) in a specific day \( t \). We denote this factor as \( n_{ct} \) and is treated as a weighting component. When used this component contains a multiplication of each value of continuous variable \( Y_{ct} \) or \( X_{ct} \) with the \( n_{jt} \) value.

Before running the estimation, the dependent variable was tested for the presence of unit root using specific panel data tests using LLC, IPS-WStat, ADF-Statistic. The null hypothesis of unit root presence was rejected each time.

### The use of GIS (Geographic Information System) tools

To obtain more insight into the geographical distribution of the manuscripts from the dataset GIS techniques and tools were used.
Spatial data was obtained from WWW5 (2017). This contains at the 0 level the country shape. Data from POP2000, which stores the country’s population was recorded for the year 2000. In this way we built a spatial database with all data (spatial and nonspatial) and so could display all the data on a map. Graduated colors allow us to emphasize the intensity of publication activity at the country level. The ArcGIS software package then implemented the spatial database and enabled us to build customized geoprocessing tools for the spatial analysis. Thus, we have three scenarios for spatial analysis:

- Compute and display the total number of papers published by corresponding authors for each country;
- Compute and display the total number of papers published by corresponding authors per population for each country (as being shown in Figure SI.1.-Supplementary Information);
- Compute and display the Localization Quotient (LQ) in order to measure the intensity of publication activity from a country taking into consideration the moment of paper submission.

We adapted a model (Furtună et al. 2013) for the Localization Quotient indicator to determine the intensity of publication activity in a country relative to the whole world. The time period can be the day, week, month or year of submission or any combination of these combined with journal filtering. Our geoprocessing tool computed the Localization Quotient indicator and displayed it on the map. The model uses as input parameters the selection expression and the number of classes. A complex expression is based on logical operators that allow to establish nonstandard time period. For instance, to select only papers submitted in TUE, WEN, THU week days, the expression is:

\[ \text{[received\_week\_day]} = 2 \text{ OR } \text{[received\_week\_day]} = 3 \text{ OR } \text{[received\_week\_day]} = 4 \]

In order to select papers submitted SAT and SUN week days and only from Cell journal, the expression is:

\[ \text{[received\_week\_day]} = 2 \text{ OR } \text{[received\_week\_day]} = 3 \text{ AND } \text{idj} = 3 \]

where \( idj \) is the field for journal identification and the 3 value identify the Cell journal.

Number of classes is used to divide the countries in many groups, each country from a group will be filled with the same color. The statistical method for data classification is Natural breaks (WWW6 2017). This method forms the groups so that the variance of the values within the class is minimal and the variation of the values among classes is maximum.

The geoprocessing model is illustrated in figure SI.2. (from the supplementary information). It uses predefined operation from ArcToolbox component and customized operations defined to compute the Localization Quotient indicator (LQ) and to apply the graduated colors symbology on maps (Simb_GC). In order to define the custom operators, it was used the Python language to write de source code, which is available within Supplementary Information section.

**Data analysis**

**Preliminary descriptive inspection**

Thanks to electronically available information we were able to study large data sets. However, the data sets only include information about papers that were accepted. This is in contrast to the smaller data set used by Hartley and Cabanac (2017) and Ausloos et al.
We find that of the accepted papers, more were submitted on week days than on weekends (Fig. 2).

Most of the accepted manuscripts are submitted on Tuesdays for Physica A (17.7%) and Nature (18.4%), On Wednesdays for PLOS ONE (18.5%) while for Cell, Mondays and Tuesdays register 18.4% each. Weekends’ submissions are more rarely being under 10% for Cell, around 11% for PLOS ONE, 12% for Nature and more than 14% in case of Physica A. No matter which journal, there are 2–3 times more published papers submitted in any week–day when compare to those which have been submitted Saturday or Sunday.

The geographic location of the papers’ corresponding authors (PCA) is another important dimension to be analyzed. Still, this is far from the current research topic. To put our data into context and as an indirect validation that our consolidated sample is consistent, a brief description from the geographical point of view is available in the supplementary Information section.

Regression analysis

We performed multiple pooled or panel regression analysis to see clearly how variation in the data depended on the day of the week a paper was submitted. Description analysis (one to one) could also provide interesting information such as we show in Figs. 2 or SI.3 and

![Graphs showing percentage submission by day of the week for different journals](image)

Fig. 2 The share of papers submitted on each day of the week for the examined journals. Note: Percentages were computed for each journal. Chi Square values were computed based on absolute figures for each journal. It is found that the grouping factor (day of the week) is statistically significant (after performing a Chi Square test: $p$ value is less than 0.01),—no matter which journal. The computed values for Chi Square test were: 994.3 (Physica A), 25,321.55 (PLOS ONE), 648.00 (Nature) and 657.82 (Cell). However, if weekends are excluded, only for PLOS ONE there are statistically significant differences among the days. The computed values for Chi Square test being: 7.47 (Physica A), 162.15 (PLOS ONE), 6.85 (Nature) and 1.34 (Cell) while the critical value is: $\chi^2_{0.05;4} = 9.49$
SI.4. However, we believe that a regression model better emphasizes the reality since more than one factor can be inserted simultaneous within the model. We are aware that there are a lot of other confounding variables (authors’ gender, age, ethnic and religious affiliation, academic–or not–position, manuscript’s number of references, time–hour/minute etc.) which are not included due to the data unavailability. Still, even with these limitations the analysis includes the regression tool in addition to the descriptive ones.

The initial estimations methods were classic OLS for article unit models, models 6–11. Several tests such as Jarque–Bera for testing the normality of residuals from regression, White or Bresuch–Pagan–Godfrey for heteroscedasticity effects of the residuals and Variance Inflation Factor (VIF) for testing the linear dependence of regressors were performed. The classical assumptions of OLS were, in majority of the cases, rejected. Thus, the residuals are not coming from a normal distribution and usually they are heteroskedastic. Moreover, the non-commune behavior or even outliers are omnipresent, affecting the assumption and the quality of the OLS results.

Hence, in order to mitigate this problem, the dependent variable was transformed as we described above and the OLS method was replaced by Robust Least Square (RLS). For the RLS method we selected a Bisquare optimization function. For the scale estimates the median centered method (MAD) was used whereas for the method, the M-estimation. The tuning parameters was kept as proposed in the paper of Holland and Welsch (1977). Our option regarding the selection of objective function, scale estimated, M-estimation method and tuning constants takes into account the spread and number of the outliers (above and below the mean) and the fact that on large samples the objective function seems not to discriminate the model regarding power (Ozlem 2011).

There is still an exception from such a rule: the robust regression method fails to estimate anything for the sample of manuscripts published by PLOS ONE. In this case, we provide only OLS estimation. When all results are analyzed we find solid evidence about consistency of the particular regression approaches, thus the existence of heteroskedasticities effects does not bias the main conclusions.

The Panel-EGLS (Wooldridge 2002) with cross-section random effects was used for model 12.

All regressions (individual journals and consolidated data: Tables 6 and 7 by time spans or by whole period) are valid (after applying ANOVA/F test) with a very good significance ($p$ value less than 0.01) while the levels of $R^2$ are varying on a wide range. This low proportion of variance for the dependent variable is expected since a limited number of factors were available for modelling. In addition, sometimes in case of such large datasets, information can be very noisy.

The first point we notice is that once the variables for day of the week are introduced, the other three groups (seasons, continents and controls) add very little new information. After each step (variable or a group of variables entered in the model) further increase of the explained variance (measured by adjusted $R^2$) for the dependent variable is always very small.

Second, no matter if it is about consolidated data set or journal specific or roll window, Weekend found to be with relevant impact both statistical and practical. Thus, every time the regression parameters were negative for that factor while statistically significant at the level 1%. Other variables testing the day of the week effect (Monday, Tuesday, Wednesday or Thursday) were more volatile.

The negative influence of Weekends submissions seems to have a rational explanation: the quality of the papers might be thought to be increased after supplementary checks performed by research teams or their peers. The “negative” accepted paper submission
| Variables/characteristics | M1 (Eq. 3) | M2 (Eq. 4) | M3 (Eq. 5) | M4 (Eq. 6) | M5 (Eq. 7) | M6 (Eq. 8) | M7 (Eq. 9) | M8 (Eq. 10) | M9 (Eq. 11) |
|---------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| **A. Consolidated data set** |            |            |            |            |            |            |            |            |            |
| Intercept                 | 0.237***   | 0.268***   | 0.277***   | 0.239***   | 0.238***   | 0.2268***  | 0.235***   | 0.234***   | 0.23***    |
| Monday (1 yes, 0 no)      | 0.01***    | 0.01***    | 0.019***   | 0.011***   | 0.011***   | 0.011***   | 0.0144***  | 0.014***   | 0.014***   |
| Tuesday (1 yes, 0 no)     | 0.087***   | 0.088***   | 0.088***   | 0.087***   | 0.087***   | 0.087***   | 0.089***   | 0.089***   | 0.089***   |
| Wednesday (1 yes, 0 no)   | 0.088***   | 0.088***   | 0.088***   | 0.087***   | 0.087***   | 0.087***   | 0.089***   | 0.089***   | 0.089***   |
| Thursday (1 yes, 0 no)    | 0.088***   | 0.088***   | 0.088***   | 0.087***   | 0.087***   | 0.087***   | 0.089***   | 0.089***   | 0.089***   |
| Weekend (1 yes, 0 no)     | -0.539***  | -0.539***  | -0.538***  | -0.541***  | -0.541***  | -0.541***  | -0.538***  | -0.538***  | -0.538***  |
| Adjusted $R^2$ (weighted) | 0.609***   | 0.0006     | 0.0015***  | 0.0014***  | 0.014***   | 0.0139***  | 0.014***   | 0.014***   | 0.014***   |
| Spring (1 yes, 0 no)      |            |            |            |            |            |            |            |            |            |
| Summer (1 yes, 0 no)      | -0.0004    | -0.0033*** | -0.0035*** | 0.0089***  | 0.008***   | 0.0091***  | 0.009***   | 0.009***   | 0.009***   |
| Fall (1 yes, 0 no)        | -0.0034*** | -0.0029*** | -0.0029*** | 0.0095***  | 0.009***   | 0.009***   | 0.009***   | 0.009***   | 0.009***   |
| Adjusted $R^2$ (weighted) | 0.00004*** | 0.607***   | 0.006***   | 0.0063***  | 0.0057***  | 0.0053***  | 0.001***   | 0.001***   | 0.001***   |
| America (1 yes, 0 no)     | 0.0091***  |            |            | 0.006***   | 0.0063***  | 0.0057***  | 0.0053***  | 0.001***   | 0.001***   |
| Africa (1 yes, 0 no)      | -0.0341*** | -0.0066*** | -0.005***  | 0.005***   | 0.005***   | 0.005***   | 0.005***   | 0.003***   | 0.003***   |
| Asia (1 yes, 0 no)        | -0.0461*** | -0.006***  | -0.005***  | -0.005***  | -0.005***  | -0.005***  | -0.005***  | -0.001***  | -0.001***  |
| Oceania (1 yes, 0 no)     | -0.0391*** | -0.01***   | -0.009***  | -0.009***  | -0.009***  | -0.009***  | -0.009***  | -0.016***  | -0.016***  |
| Adjusted $R^2$ (weighted) | 0.001***   | 0.607***   | 0.0125***  | 0.0125***  | 0.0126***  | 0.0126***  | 0.0126***  | 0.0126***  | 0.0126***  |
| Christmas (1 yes, 0 no)   |            |            |            |            |            |            |            |            |            |
| Adjusted $R^2$ (weighted) |            |            | 0.0047***  | 0.005***   | 0.005***   | 0.0046***  | 0.0046***  | 0.0046***  | 0.0046***  |
| $\log_{10}$AUTHORS        |            |            |            |            |            |            |            |            |            |
| Adjusted $R^2$ (weighted) |            |            |            |            |            |            |            |            |            |
| $\log_{10}$HDI            |            |            |            |            |            |            |            |            |            |
| Adjusted $R^2$ (weighted) |            |            |            |            |            |            |            |            |            |

Table 6: Regression estimates for the dependent variables for consolidated data set and each journal for each model.
Table 6 continued

| Variables/characteristics | Models |
|---------------------------|--------|
|                           | M1 (Eq. 3) | M2 (Eq. 4) | M3 (Eq. 5) | M4 (Eq. 6) | M5 (Eq. 7) | M6 (Eq. 8) | M7 (Eq. 9) | M8 (Eq. 10) | M9 (Eq. 11) |
| log₁₀LTO                  | -0.013*** | -0.013*** | -0.012** | -0.018** | -0.018** | -0.018** | -0.018** | -0.016* | -0.012*** |
| Adjusted $R^2$            | 0.602*** | 0.602*** | 0.602*** | 0.602*** | 0.602*** | 0.602*** | 0.602*** | 0.602*** | 0.602*** |

B. Physica A: Statistical mechanics and its applications

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Intercept | 0.200*** | 0.183*** | 0.2033*** | 0.200*** | 0.213** | 0.200*** | 0.212*** | 0.214*** | 0.227*** |
| Monday (1 yes, 0 no) | 0.020** | 0.020** | 0.020** | 0.018** | 0.018** | 0.018** | 0.018** | 0.016* | 0.012 |
| Tuesday (1 yes, 0 no) | 0.015* | 0.015* | 0.015* | 0.0147 | 0.014 | 0.014 | 0.014 | 0.014 | 0.011 |
| Wednesday (1 yes, 0 no) | 0.013 | 0.014 | 0.014 | 0.014 | 0.013 | 0.014 | 0.014 | 0.014 | 0.011 |
| Thursday (1 yes, 0 no) | 0.007 | 0.007 | 0.007 | 0.0069 | 0.006 | 0.006 | 0.006 | 0.006 | 0.003 |
| Weekend (1 yes, 0 no) | -0.215*** | -0.215*** | -0.212*** | -0.213*** | -0.213*** | -0.213*** | -0.214*** | -0.214*** | -0.219*** |
| Adjusted $R^2$ (weighted) | 0.104*** | 0.104*** | 0.104*** | 0.104*** | 0.104*** | 0.104*** | 0.104*** | 0.104*** | 0.104*** |
| Spring (1 yes, 0 no) | -0.007 | -0.006 | -0.005 | 0.008 | 0.008 | 0.009 | 0.009 | 0.009 | 0.009 |
| Summer (1 yes, 0 no) | -0.003 | 0.002 | 0.002 | 0.016** | 0.016** | 0.017** | 0.017** | 0.017** | 0.017** |
| Fall (1 yes, 0 no) | 0.0001 | 0.0006 | 0.0004 | 0.014* | 0.014* | 0.015* | 0.015* | 0.015* | 0.016** |
| Adjusted $R^2$ (weighted) | 0.0001*** | 0.104*** | 0.104*** | 0.104*** | 0.104*** | 0.104*** | 0.104*** | 0.104*** | 0.104*** |
| America (1 yes, 0 no) | -0.0092 | -0.006 | -0.006 | -0.005 | -0.005 | -0.003 | 0.009 | 0.009 | 0.009 |
| Africa (1 yes, 0 no) | -0.0041 | 0.02 | 0.019 | 0.02 | 0.029 | 0.06** | 0.06** | 0.06** | 0.06** |
| Asia (1 yes, 0 no) | -0.0437*** | -0.025*** | -0.025*** | -0.022*** | -0.022*** | -0.017** | -0.019*** | -0.019*** | -0.019*** |
| Oceania (1 yes, 0 no) | -0.0594*** | -0.068*** | -0.066*** | -0.066*** | -0.066*** | -0.069*** | -0.069*** | -0.069*** | -0.069*** |
| Adjusted $R^2$ (weighted) | 0.007*** | 0.107*** | 0.107*** | 0.107*** | 0.107*** | 0.107*** | 0.107*** | 0.107*** | 0.107*** |
| Christmas (1 yes, 0 no) | 0.081*** | 0.08*** | 0.081*** | 0.082*** | 0.082*** | 0.082*** | 0.082*** | 0.082*** | 0.082*** |
| Adjusted $R^2$ (weighted) | 0.111*** | 0.111*** | 0.111*** | 0.111*** | 0.111*** | 0.111*** | 0.111*** | 0.111*** | 0.111*** |
| log₁₀AUTHORS | -0.0146*** | -0.0146*** | -0.0146*** | -0.012** | -0.012** | -0.012** | -0.012** | -0.012** | -0.012** |
| log₁₀HDI | 0.03 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 |
Table 6 continued

| Variables/characteristics | Models |
|--------------------------|--------|
|                           | M1 (Eq. 3) | M2 (Eq. 4) | M3 (Eq. 5) | M4 (Eq. 6) | M5 (Eq. 7) | M6 (Eq. 8) | M7 (Eq. 9) | M8 (Eq. 10) | M9 (Eq. 11) |
| Adjusted $R^2$ (weighted) | 0.113*** | 0.041**    |            |            |            |            |            |            |            |
| log$_{10}$LTO              | 0.041**    |            |            |            |            |            |            |            |            |
| Adjusted $R^2$             | 0.116*** |            |            |            |            |            |            |            |            |
| C. PLOS ONE                |         |            |            |            |            |            |            |            |            |
| Intercept                 | 0.308*** | 0.338*** | 0.343*** | 0.326*** | 0.328*** | 0.291*** | 0.292*** | 0.294*** | 0.29***    |
| Monday (1 yes, 0 no)      | 0.021*** | 0.021*** | 0.021*** | 0.021*** | 0.021*** | 0.021*** | 0.021*** | 0.021*** | 0.021***   |
| Tuesday (1 yes, 0 no)     | 0.11***   | 0.111*** | 0.111*** | 0.111*** | 0.111*** | 0.112*** | 0.112*** | 0.111*** | 0.111***   |
| Wednesday (1 yes, 0 no)   | 0.126***  | 0.126*** | 0.127*** | 0.128*** | 0.128*** | 0.128*** | 0.128*** | 0.127*** | 0.127***   |
| Thursday (1 yes, 0 no)    | 0.113***  | 0.114*** | 0.114*** | 0.114*** | 0.114*** | 0.114*** | 0.114*** | 0.114*** | 0.114***   |
| Weekend (1 yes, 0 no)     | 0.481***  | 0.481*** | 0.478*** | 0.48***  | 0.48***  | 0.48***  | 0.48***  | 0.48***  | 0.481***   |
| Adjusted $R^2$            | 0.352***  |            |            |            |            |            |            |            |            |
| Spring (1 yes, 0 no)      | -0.015*** | -0.02***  | -0.02***  | 0.017*** | 0.017*** | 0.017*** | 0.017*** | 0.017*** | 0.017***   |
| Summer (1 yes, 0 no)      | -0.018*** | -0.024*** | -0.025*** | 0.013*** | 0.013*** | 0.013*** | 0.013*** | 0.013*** | 0.013***   |
| Fall (1 yes, 0 no)        | -0.021*** | -0.025*** | -0.025*** | 0.013*** | 0.013*** | 0.013*** | 0.013*** | 0.013*** | 0.013***   |
| Adjusted $R^2$            | 0.001***  | 0.353***  |            |            |            |            |            |            |            |
| America (1 yes, 0 no)     | 0.001     | 0.005***  | 0.004***  | 0.004***  | 0.004***  | 0.004***  |              |            |            |
| Africa (1 yes, 0 no)      | -0.04***  | -0.014*** | -0.016*** | -0.016*** | -0.016*** | -0.006   | -0.014*   |            |            |
| Asia (1 yes, 0 no)        | -0.058*** | -0.013*** | -0.015*** | -0.015*** | -0.015*** | -0.011*** | -0.008*** |            |            |
| Oceania (1 yes, 0 no)     | -0.043*** | -0.013*** | -0.012*** | -0.012*** | -0.012*** | -0.013*** | -0.02***  |            |            |
| Adjusted $R^2$            | 0.008***  | 0.354***  |            |            |            |            |            |            |            |
| Christmas (1 yes, 0 no)   |               |            |            | 0.193***  | 0.193***  | 0.192***  | 0.192***  |            |            |
| Adjusted $R^2$            |               |            |            | 0.369***  | 0.369***  | 0.369***  | 0.369***  |            |            |
| log$_{10}$AUTHORS         |               |            |            |              |              | -0.0009   | -0.001    | -0.0003   |            |
| Adjusted $R^2$            |               |            |            |              |              | 0.369***  |            |            |            |
| Variables/characteristics | Models |
|--------------------------|--------|
|                          | M1 (Eq. 3) | M2 (Eq. 4) | M3 (Eq. 5) | M4 (Eq. 6) | M5 (Eq. 7) | M6 (Eq. 8) | M7 (Eq. 9) | M8 (Eq. 10) | M9 (Eq. 11) |
| log₁₀HDI                 | 0.051*** | 0.063***  |
| Adjusted $R^2$           | 0.367*** |
| log₁₀LTO                 |        |
| Adjusted $R^2$           |        |
|                          | 0.368*** |
| D. Nature                |        |
| 0                        |        |
| Intercept                | 0.313*** | 0.294***  | 0.2607***   | 0.32***  | 0.313***   | 0.303***   | 0.303***   | 0.305***   | 0.298***   |
| Monday (1 yes, 0 no)     | 0.073   |          |            |          |            |            |            |            |            |
| Tuesday (1 yes, 0 no)    | -0.001* | -0.0009  | -0.001     | -0.0008  | -0.0008    | -0.0009    | -0.0009    | -0.0009    | -0.0009    |
| Wednesday (1 yes, 0 no)  | -0.016*** | -0.017** | -0.0169**  | -0.016** | -0.016**   | -0.016**   | -0.016**   | -0.0159**  | -0.0159**  |
| Thursday (1 yes, 0 no)   | -0.033*** | -0.032*** | -0.030***  | -0.030*** | -0.030***  | -0.030***  | -0.030***  | -0.030***  | -0.030***  |
| Weekend (1 yes, 0 no)    | -0.188*** | -0.188*** | -0.187***  | -0.187*** | -0.187***  | -0.187***  | -0.187***  | -0.187***  | -0.187***  |
| Adjusted $R^2$ (weighted)| 0.19*** |
| Spring (1 yes, 0 no)     |        |
| -0.021***                | -0.017** | -0.018*** | -0.008     | -0.008    | -0.008     | -0.008     | -0.008     | -0.008     |
| Summer (1 yes, 0 no)     |        |
| -0.005                   | -0.004  | -0.004    | 0.004      | 0.004     | 0.004      | 0.004      | 0.004      | 0.004      |
| Fall (1 yes, 0 no)       |        |
| -0.005                   | -0.005  | -0.005    | 0.003      | 0.003     | 0.003      | 0.003      | 0.003      | 0.003      |
| Adjusted $R^2$ (weighted)| 0.003*** | 0.19***  |
| America (1 yes, 0 no)    | 0.0073  | 0.011**   | 0.011**    | 0.011**   | 0.011**    | 0.011**    | 0.011**    | 0.0002     |
| Africa (1 yes, 0 no)     | 0.0033  | 0.001     | 0.002      | 0.002     | 0.002      | 0.002      | 0.002      | 0.0238     |
| Asia (1 yes, 0 no)       | 0.0041  | 0.009     | 0.01       | 0.01      | 0.01       | 0.01       | 0.01       | 0.015      |
| Oceania (1 yes, 0 no)    | -0.0046 | 0.01      | 0.01       | 0.01      | 0.01       | 0.01       | 0.01       | -0.003     |
| Adjusted $R^2$ (weighted)| 0.001*** | 0.192*** |
| Christmas (1 yes, 0 no)  |        |
| 0.07***                  | 0.07***  | 0.07***   | 0.07***    | 0.07***   |
| Adjusted $R^2$ (weighted)|        |
| 0.197***                 |        |
| log₁₀AUTHORS             |        |
| 0.0001                   | 0.0001  | 0.00019   |
| Variables/characteristics | Models         | M1 (Eq. 3) | M2 (Eq. 4) | M3 (Eq. 5) | M4 (Eq. 6) | M5 (Eq. 7) | M6 (Eq. 8) | M7 (Eq. 9) | M8 (Eq. 10) | M9 (Eq. 11) |
|--------------------------|----------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| **Adjusted $R^2$ (weighted)** |                | 0.197***   | 0.021      | 0.018      |            |            |            |            |            |            |
| **log$_{10}$HDI**        |                |            |            |            | 0.197***   | 0.029      |            |            |            |            |
| **Adjusted $R^2$ (weighted)** |                |            |            |            |            | 0.197***   |            |            |            |            |
| **log$_{10}$LTO**        |                |            |            |            |            |            |            |            |            | −0.029     |
| **Adjusted $R^2$**        |                |            |            |            |            |            |            |            |            | 0.197***   |
| E. Cell                  |                |            |            |            |            |            |            |            |            |            |
| 0                        |                |            |            |            |            |            |            |            |            |            |
| Intercept                | 0.3001***       | 0.3107***  | 0.2964***  | 0.3132***  | 0.3063***  | 0.2941***  | 0.2964***  | 0.288***   | 0.2756***  |
| Monday (1 yes, 0 no)     | 0.0421***       |            |            |            | 0.0428***  | 0.0423***  | 0.0413***  | 0.0412***  | 0.0414***  |
| Tuesday (1 yes, 0 no)    | 0.0149          |            |            |            | 0.0312     | 0.0135     | 0.0127     | 0.0126     | 0.0128     |
| Wednesday (1 yes, 0 no)  | 0.0055          |            |            |            | 0.0037     | 0.0036     | 0.002      | 0.0019     | 0.0019     |
| Thursday (1 yes, 0 no)   | 0.003           |            |            |            | 0.0023     | 0.0028     | 0.0025     | 0.0025     | 0.002      |
| Weekend (1 yes, 0 no)    | −0.1416***      |            |            |            | −0.1428*** | −0.143***  | −0.1431*** | −0.1431*** | −0.143***  |
| **Adjusted $R^2$ (weighted)** | 0.0468***       |            |            |            |            |            |            |            |            |
| Spring (1 yes, 0 no)     | −0.0257***      |            |            |            | −0.0275**  | −0.0269**  | −0.0136    | −0.0136    | −0.0135    |
| Summer (1 yes, 0 no)     | −0.0286**       |            |            |            | −0.0274**  | −0.027**   | −0.0136    | −0.0136    | −0.0135    |
| Fall (1 yes, 0 no)       | 0.0116          |            |            |            | 0.0119     | 0.0118     | 0.0251**   | 0.0251**   | 0.0252**   |
| **Adjusted $R^2$ (weighted)** | 0.0059***       |            |            |            |              | 0.0536***  |            |            |            |
| America (1 yes, 0 no)    | −0.0002         | 0.0059     | 0.0054     | 0.0053     | 0.0059     | 0.0212     |            |            |            |
| Africa (1 yes, 0 no)     | 0.0709          | 0.088      | 0.0869     | 0.0864     | 0.0569     | 0.045      |            |            |            |
| Asia (1 yes, 0 no)       | 0.0271          | 0.0307**   | 0.0303*    | 0.0303*    | 0.022      | 0.0292     |            |            |            |
| Oceania (1 yes, 0 no)    | 0.0758          | 0.0607     | 0.0609     | 0.0612     | 0.0637     | 0.0294     |            |            |            |
| **Adjusted $R^2$ (weighted)** | 0.0017***       |            |            |            |              |            |            |            |            |
| Christmas (1 yes, 0 no)  | 0.0842***       | 0.0842***  | 0.0845***  | 0.0846***  |            |            |            |            |            |
| **Adjusted $R^2$ (weighted)** | 0.0597***       |            |            |            |              |            |            |            |            |
Table 6 continued

| Variables/characteristics | Models                      |                |                |                |                |                |                |                |                |
|---------------------------|-----------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
|                           | M1 (Eq. 3)                  | M2 (Eq. 4)     | M3 (Eq. 5)     | M4 (Eq. 6)     | M5 (Eq. 7)     | M6 (Eq. 8)     | M7 (Eq. 9)     | M8 (Eq. 10)    | M9 (Eq. 11)    |
| log_{10}AUTHORS           | -0.001                      | -0.001         | -0.0007        |                |                |                |                |                |                |
| Adjusted $R^2$ (weighted) | 0.0597***                   |                |                |                |                |                |                |                |                |
| log_{10}HDI               | -0.0934                     | -0.0713        |                |                |                |                |                |                |                |
| Adjusted $R^2$ (weighted) | 0.0597***                   |                |                |                |                |                |                |                |                |
| log_{10}LTO               | -0.0697                     |                |                |                |                |                |                |                |                |
| Adjusted $R^2$            | 0.0599***                   |                |                |                |                |                |                |                |                |

*Statistically significant at level 10%
**Statistically significant at level 5%
***Statistically significant at level 1%
effect during the week-end might be related to geography. There is an important share of population around the world (e.g. Muslim) which rest on Friday and works on Sunday. Of course, one might say that an important proportion of the people are not doing anything professional on weekends, neither writing, researching nor submitting.

Thirdly, the estimated regression parameters for Christmas are always positive (no matter if it is about the consolidated data set or specific journal samples). With regard to this outcome, we note that scholars tend to submit papers during Christmas time more often than in other periods.

Apart of the negative Weekends submissions effect, a closer look at the day of the week group of variables is necessarily since, as we mentioned above this is the most important one. Due to the size effect, PLOS ONE sample seems to drive the outcomes of the consolidated dataset. Indeed, for this two samples, the regression’s coefficients for all factors (Monday, Tuesday, Wednesday and Thursday) are synchronized: all of them are positive while their effective values are 4–5 times bigger for Tuesday, Wednesday and Thursday when compare to Monday. Since Friday was the reference point for this group, this means that for PLOS ONE accepted submissions are most likely to happen Tuesday, Wednesday and Thursday when compare to Monday. This is an analytical confirmation of the visual information presented for PLOS ONE earlier (Fig. 2). For Nature sample, there are two factors (Wednesday and Thursday) which are, while statistically significant, negative. The effective values for the regression’s coefficients in this case are 4–10 times smaller while compare to Weekends. This means that apart to weekend,
accepted submissions to Nature occurs usually not Wednesday or Thursday. The Cell and Physica A sample shown a clear positive Monday effect while for some simpler (not with so many control factors inserted) models, for Physica A a positive Tuesday effect is visible.

As mentioned in the Materials and methods section, the seasonality is checked systematically. As we mention above, this variables group is adding only a tiny fraction of new information within all models. Let us split again our comments, first to look to the consolidated data set and its main driver (the PLOS ONE sample) together and after to have an opinion about the other three samples (Physica A, Nature and Cell). Due to the very large number of cases, for the consolidated and PLOS ONE data sets, every seasonal factor which is inserted in the model prove to be statistical significant. Still, there is a sign volatility (models M1–M5 versus M6–M9). This is a classical sign for multicollinearity. Indeed, the correlations matrix (Table SI.2 from Supplementary Information) for this samples shows negative Pearson’s correlation coefficients between seasons with effective values between 0.33 and 0.35 and also a negative relationship to Christmas (correlation coefficients around 0.13–0.14). In this context, the sign volatility between models M1–M5 and M6–M9 appears to be natural since the control factor (Christmas) is present within models M6–M9. The outcomes for the other three samples (Physica A, Nature and Cell) show the same signs volatility. In addition, sometimes there is also a statistical significance volatility (M1–M5 versus M6–M9). The main reason for this volatility is the same: a persistent correlation between seasonal and Christmas factors. Also, the statistical significance volatility could occur due to smaller samples (size effect) under weak factors’ correlations within the dependent variables.

The geographical factors from the regression models (America, Africa, Asia, and Oceania while Europe is the reference) are many times statistically insignificant. This geographic volatility (in terms of how many times a factor is statistical significant and how many times there is a change in the sign of the estimated parameter) needs a deeper analysis. The most probable explanation for this volatility is similar to the seasonal factors. There is a sample size effect: as long as the samples are bigger (consolidated data set, PLOS ONE and, in a lesser amount, Physica A) the signs and statistical significance volatility remains lower. Due to the weaker correlation to the dependent variable and persistent negative correlations between geographical factors, when smaller samples are analyzed the outcomes tend to be volatile.

Due to the large number of models and samples when one is multiplying using the predefined roll windows, the outcomes (tens of pages of information) exceed the limited space available within a regular paper. Therefore, all detailed outcomes of the regression models for each roll window are available within Table SI.3. from the Supplementary Information while a brief visual presentation about regression coefficients’ signs and their significance is available within Fig. 3.

Since the samples’ size for each roll window became smaller and smaller, as expected, sometimes the volatility of the regression coefficients or their statistical significance became greater. Even so, the main conclusions: most important factor (Weekend); most important group of factors (days of the week) and most important control factor (Christmas) still stand.

The results achieved after the panel analysis are convergent with those achieved under the unstructured sample. Here another proof for a significant impact of the week–day on the dependent variable emerges. Also it can be highlighted that other factors such as LTO or HDI are rather non-significant. The unobserved cross-sectional factors are found to be not relevant in the panel structure, as their share in total variation of the unobserved factors is almost zero (Table 7).
**Physica A**

|                      | Tuesday | Wednesday | Thursday | Weekend |
|----------------------|---------|-----------|----------|---------|
| Log10LTO             | 12      | 8         |          |         |
| Log10HDI             | 8       |           |          |         |
| Log10Authors         | 3       |           |          |         |
| Log10Christmas       | 6       |           |          |         |
| Oceania              | 12      | 8         |          |         |
| Asia                 | 12      | 8         |          |         |
| Africa               | 12      | 8         |          |         |
| America              | 12      | 8         |          |         |
| Fall                 | 12      | 8         |          |         |
| Summer               | 12      | 8         |          |         |
| Spring               | 12      | 8         |          |         |
| Intercept            | 45      |           |          |         |

**PLOS ONE**

|                      | Tuesday | Wednesday | Thursday | Weekend |
|----------------------|---------|-----------|----------|---------|
| Log10LTO             | 4       | 2         |          |         |
| Log10HDI             | 4       |           |          |         |
| Log10Authors         | 4       | 2         |          |         |
| Log10Christmas       | 4       | 2         |          |         |
| Oceania              | 4       | 2         |          |         |
| Asia                 | 4       | 2         |          |         |
| Africa               | 4       | 2         |          |         |
| America              | 4       | 2         |          |         |
| Fall                 | 4       | 2         |          |         |
| Summer               | 4       | 2         |          |         |
| Spring               | 4       | 2         |          |         |
| Intercept            | 4       | 2         |          |         |

![Fig. 3](image-url) Distributions of regression coefficients’ signs. *Note:* “+ *” denotes a statistically significant positive coefficient, “+” denotes a positive coefficient, “+ ?” denotes a coefficient for which the standard error could not be computed and, therefore, the t test for testing statistical significance is unavailable. The notations for negative coefficients are similar.
The regression methods signaled (on the consolidated dataset) that there are some patterns within the propensity of submitting papers Tuesday and Wednesday (while Friday was the reference day). On the other hand, accepted manuscripts submissions tend to be lower (negative regression coefficients) especially for weekends but also slightly so for Monday.

**Spatial analysis**

The regression methods signaled (on the consolidated dataset) that there are some patterns within the propensity of submitting papers Tuesday and Wednesday (while Friday was the reference day). On the other hand, accepted manuscripts submissions tend to be lower (negative regression coefficients) especially for weekends but also slightly so for Monday.
Therefore, we create two daily intervals: Tuesday–Thursday and Saturday–Monday. With a methodology presented in Materials and Methods section an indicator: Localization Quotient (LQ) is introduced using GIS tools for both above-mentioned daily intervals. The outcomes are interesting and shown in the Figs. 4 and 5. The figures are complementary. In Fig. 4, countries which tend to submit papers during Tuesday–Thursday (TUE–THU) with a greater intensity than the world average submission rate for the same interval (TUE–THU) are highlighted by dark brown. This group comprises countries like: Belarus, Belize, Benin, Bosnia and Herzegovina, Greenland, Haiti, Iraq, Mauritania, Namibia, Nicaragua, and Syria. Every continent except Oceania is represented in this list. As expected, most of the important countries (who, by size, have an important weight over the world average) register a level of LQ between 93.33 and 136.5% of the world average TUE–THU submission rate.

A greater heterogeneity of the countries distribution by LQ designed for Saturday–Monday (SAT–MON) interval is easy to be seen in Fig. 5. Countries that register low levels on the previous map are now concentrated in two leading groups. The first one is formed by two countries: Nigeria and Yemen. Their propensity of submitting papers during SAT–MON interval is more than twice as big as the world average. The second group register a propensity of submitting papers during SAT–MON interval greater than world average by a multiplier between 1.35 and 2.39. In this group countries like: Angola, Armenia, Burkina Faso, Central African Republic, Georgia, Iran, Ivory Coast, Libya, Mali, Macedonia, Moldova, Mongolia, Myanmar, Oman, Saudi Arabia, and Sri Lanka are included. Many of these countries belonging to the lead groups are known for their important Muslim population. Further research should be done on this topic.
Conclusions and discussion

In line with other reports (Cabanac and Hartley 2013; Campos-Arceiz et al. 2013; Hartley and Cabanac 2017; Ausloos et al. 2016, 2017) our results confirm a DWE for published papers. Papers accepted for publication in the four journals included in our analysis are more likely to have been submitted on a week–day than on a day in the week-end. There are 2–3 times more published papers submitted in any week–day when compare to those which have been submitted Saturday or Sunday. The most likely week–day for historical accepted submissions differs from journal to journal. In the case of PLOS ONE there is a group of 3 days: Tuesday, Wednesday and Thursday; for Physica A there are two consecutive days: Monday and Tuesday; for Nature, there are 2 days: Friday and Monday while for Cell only Monday.

Most of the seasonal factors proved to be statistical insignificant. However, the Christmas period (20th of December to 10th of January) has a statistically significant positive impact. More papers tend to be submitted in that time interval.

The geographical dimension (papers’ corresponding authors’ affiliation country) brings new information concerning how current research is done (descriptive: GIS and analytical—a mix of log–log and semi-log based on undated and panel structured data regression models). Further work on this aspect would be interesting even if most geographical driven factors from the regression models provide a weak explanatory power.

In addition to the day of the week, time is included here and examined from different perspective, namely the time trends in the data. The most important factors for the main
topic of the manuscript (Week–days and Week-end) tend to be stable. Of course, some fluctuations occur for other factors. The yearly time span from our data set is not long enough to use other specific time series techniques. This is a topic for further study.

Supplementary information

All information about each annual dataset on which the current paper relies is available from Excel file: Table_SI.1.xlsx. The customized script for all four journals analyzed in the current paper is available in the following Word file: SI_Scraper.docx. The Python’s scripts are available in Word File: SI_Python_Scripts.docx. The correlations matrix for all samples are available within the Word file: Table_SI.2.docx. The regression analysis outcomes for roll windows are available within: Table_SI.3.docx. The detailed formula of Kurtosis is available within SI_Kurtosis.docx. The Geographical presentation of our consolidated dataset is available in: SI_Geographical.docx. Four supplementary figures (SI.1., SI.2., SI.3. and SI.4.) are available in Word Files: Figure_SI_1.docx, Figure_SI_2.docx, Figure_SI_3.docx and Figure_SI_4.docx.

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Compliance with ethical standards

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

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