New Avenues for Electronic Publishing in the Age of Infinite Collections and Citizen Science
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Data Policies and Data Archives: A New Paradigm for Academic Publishing in Economic Sciences?

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Abstract. In our paper we summarise the findings of an empirical study in which a sample of 346 journals in economics and business studies were examined. We regard both the extent and the quality of journals' data policies, which should facilitate replications of published empirical research. The paper presents some characteristics of journals equipped with data policies and gives some recommendations for suitable data policies in economics and business sciences journals. In addition, we also evaluate the journals' data archives to roughly estimate whether these journals really enforce data availability. Our key finding is that we are currently not able to determine a new publishing paradigm for journals in economic sciences.

Keywords: Reproducibility, replication, economics, business studies, social sciences, academic publishing, data policies, data archives.

1. Introduction

In economic sciences, empirically based studies have become increasingly important: The number of contributions to journals in which authors utilised self-collected or externally produced datasets for statistical analyses have massively increased [1].

With the growing relevance of publications based on empirical research, new questions and challenges for academic publishing emerge. Issues like integrating research data and scripts to run a data model in the broader context of a published article to foster replicable research and validation of scientific results are becoming increasingly important for both researchers and editors of scholarly journals.

This growing importance of research data and its integration in the academic publishing process is also reflected in numerous statements and partially also in requirements of funding agencies and scientific and political bodies in Europe and abroad. For instance, the European Commission (EC) recommends that EU member states should implement policies to ensure that "datasets are made easily identifiable and can be linked to other datasets and publications through appropriate mechanisms" [2]. This is also reflected in the goals of the 8th research framework programme of the EC, better known as Horizon 2020, inter alia the open research data pilot, which aims to improve and maximise access to and re-use of research data generated by funded projects [3].

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To date, there exist only few means to replicate the results of economic research within the framework of published journal articles and to verify the results claimed in such a paper. This is unsatisfactory from a scientific point of view, because replicability is a cornerstone of the scientific method. The US economist B.D. McCullough outlined the importance of replicable research: "*[…] replication ensures that the method used to produce the results is known. Whether the results are correct or not is another matter, but unless everyone knows how the results were produced, their correctness cannot be assessed. Replicable research is subject to the scientific principle of verification; non-replicable research cannot be verified. Second, and more importantly, replicable research speeds scientific progress. […] Third, researchers will have an incentive to avoid sloppiness. […] Fourth, the incidence of fraud will decrease"*[4].

Especially for a scientific discipline like economic sciences, the effects of flawed research might have a huge impact on society, as the prominent example of the US economists Reinhart and Rogoff illustrated: The two top economists had published a paper [5] on the interrelation of economic growth and public debt in 2010 that attracted much attention: US vice presidential candidate Paul Ryan and also EU monetary affairs commissioner Olli Rehn used the findings claimed in the paper to justify austerity policy [6].

In 2013, the two authors provided the Excel sheet of their calculations to a student for teaching purposes. This student discovered that the Excel sheet contained faulty calculations and selectively omitted data [7], which casted massive doubts on Reinhart's and Rogoff's findings. This example clearly illustrates the necessity for economic research to be replicable.

One possible way to facilitate replications of published research is to implement strict research data policies for journals and also to implement data archives for code and data associated with articles published in scientific journals. But currently, especially professionally maintained data archives for publication-related research data in the social and economic sciences are not widespread. Often such data centres exist only for large surveys [23]. Therefore, a growing number of organisations and initiatives from all over the world have started to offer suitable services. Examples include the Interuniversity Consortium for Political and Social Research (ICPSR) (US)[2], GESIS-datorium (DE)[3], DANS-EASY (NL)[4] and the UK Data Service ReShare (UK)[5].

For our project[6] the question arose, how many journals in economic sciences currently are equipped with policies which facilitate access to underlying research data and the code of computation, which supports replications of applied economic research. To evaluate the current status quo in economic sciences and to clarify whether the implementation of data policies and related data archives tend to be a new paradigm for economic research, our project conducted a broad evaluation of 346 journals in economics and business studies. In addition, we also examined the way in which journals provide researchers and interested readers with research data and other materials.

[2] Cf. http://www.icpsr.umich.edu/icpsrweb/deposit/

[3] Cf. https://datorium.gesis.org/xmlui/?locale-attribute=en

[4] Cf. https://easy.dans.knaw.nl/ui/deposit

[5] Cf. http://reshare.ukdataservice.ac.uk/

[6] These project results have been developed in the EDaWaX project (European Data Watch Extended, http://www.edawax.de). EDaWaX is financed by the German Research Foundation (http://www.dfg.de).

2. Literature Review

To date, not many economists have dealt with the topic of data policies, despite the fact that discussion around replicable research in the discipline has been ongoing for several decades now. In 1986, a broadly noticed paper [8] reported the findings of a two-year study that collected programs and data from authors and attempted to replicate their published results. Ultimately, the authors were able to replicate only 2 of 54 papers – 3.7%.

Data policies of journals, especially the data policy of the Journal of Money, Credit and Banking (JMCB), which in 1982 was one of the first journals to introduce a data policy, were already discussed in the paper.

Almost 20 years later, the US economist B.D. McCullough published remarkable articles on data policies and data availability in economic journals. McCullough analysed the data policies of selected journals [9] and their data archives [10]. In 2008, he broadened his analyses and checked the data policies and data archives of journals in regard to their functionality for replication purposes [11]. One year later, he recapped his findings and also discussed the open access question for economic research. In total, he was not able to find more than 11 journals equipped with a mandatory data and code archive within the top 50 economics journals [4].

For our project the question arose, how the "market for replicable economic research" has developed since 2009. A first attempt was published in 2013, using a sample of 141 economics journals [12]. We found a total of 40 journals equipped with a data policy. 29 journals had a data availability policy[7], another 11 held weak policies which ask authors to cooperate with researchers in case of future request for data. Therefore, we name these policies author responsibility policies (in the following abbreviated with "ARP"). In addition, we found that journals with a data availability policy (in the following abbreviated with "DAP") are much better rated than journals without such policy. These findings are in line with other disciplinary and interdisciplinary studies [13, 14].

In addition, our project published some insights on the current status quo in providing research data in economics journals and the extent to which journals enforce data availability and replicable research. Our findings suggest that the main way to provide research data and associated materials is via the journals' websites. But we also noticed that journals obviously do not really enforce data availability: Only eight out of 29 journals had more than 50% of all articles in two issues checked accompanied by research data; 10 out of 29 journals with a DAP did not even have a single article in their archive supplemented by research data [12].

3. Study Methodology and Characteristics of the Research Sample

To compile a sample for our analyses, we used several lists of academic journals assembled by German economic associations. For instance, we included the

[7] We distinguish two types of data policies: An "author responsibility policy" requires authors to provide data (and sometimes code and other materials, too) to would-be replicators. In contrast, a data availability policy asks or mandates authors to provide research data (and partially code and other associated materials) to the journal. The journal provides this information to would-be replicators by attaching the data and other materials to the article (often in the "supplementary information" section). Cf. McCullough, McGeary & Harrison (2008) [11].

JOURQUAL2.1 list [15], maintained by the German Academic Association for Business Research (VHB), for journals in business studies. In addition, we included a sample of journals used by Bräuninger, Haucap and Muck [16], which primarily focuses on journals in economics. Both lists of journals have been used to evaluate the quality and relevance of the included journals from the point of view of German economists.

Because the JOURQUAL list contains 838 journals, we had to select a subsample. Therefore, we chose all journals from the JOURQUAL list ranked A+, A or B. This selection criterion is based on the results of our analyses in project phase 1, during which we found that primarily high-ranked journals are equipped with DAPs [12].

Using this approach, 258 out of 838 journals remained in the sample. Additionally, we randomly selected 60 journals rated C, D or E. With the aid of this subsample, we again wanted to check whether our assumption regarding the interrelation of highly ranked journals and the existence of data policies is correct. The entire sample used by Bräuninger, Haucap and Muck was also added to our research sample. In the next step, we removed double entries (some journals in the Bräuninger, Haucap and Muck sample are also included in the JOURQUAL list) and carefully checked the "aims and scope" section of each journal to find out whether the particular journal generally publishes empirically based studies and research papers. Journals publishing only theoretical papers or papers based on policy debates were removed from our sample.

Due to the outcome of this examination, the sample's size slightly decreased: In total, our database contains 346 journals, which is still quite a big sample compared to similar analyses.

Subsequently, we determined the primary scope of all journals in our sample. With such a classification, we were able to differentiate the results of our study by the subdomains of economic research. The lists of journals provided by professional associations are not sufficient for this purpose, because they do not distinguish accurately among subject categories. Therefore, we employed the subject categories used by the Thomson Reuters Journal Citation Report (JCR). In the event of more than one subject category being listed in the JCR, we used all of those, as long as all subject categories are derived from the broader field of economic research (we named this category 'economics & business studies in equal parts'). In the event of only one of the categories being dedicated to the field of economic research, we only used this subject category (either 'primarily economics' or 'primarily business studies'). In the case of none of the subject categories being primarily dedicated to economic research, we assigned the journal to a group called 'other'. For journals not listed in the JCR, we employed the indexing guidelines of the ZBW (German National Library of Economics/Leibniz Information Centre for Economics) to determine the subject category.

Beyond this, we also collected further information on the journals in our sample. For instance, we collected the impact factor of these journals (if available) and the rating both in the JOURQUAL2.1 and in the Handelsblatt ranking [17] – the latter being an important ranking for German economists.

Subsequently, we checked the websites of the journals (in some cases there are two websites for a single journal – the publisher's website and a website maintained by the editors) for existing data policies. In cases where we found such a guideline, we carefully analysed the wording of each policy and checked whether the policy complies with the criteria listed below. These criteria have been derived from previous studies in the field of replicable economic research [4, 8, 9, 10, 18]:

- A data policy must be mandatory.
- A data policy should not only require authors to provide the datasets used, but also the code of computation (syntax), self-compiled software components (e.g. in Fortran) and detailed descriptions of the data (data dictionary or codebook). In addition, such a policy should mandate authors to submit the original data from which the final dataset is derived and all instructions/codes necessary to achieve the final results of computation. Also, a README file should list all submitted files with a description of each and indicate which programs correspond to which findings in the paper.
- The data policy should require authors of empirically based articles to provide data and other materials listed above to the editorial office prior to the publication of an article.
- All submitted data and files (apart from confidential or proprietary datasets) must be made publicly available by the journal to interested researchers.
- A data policy has to have a procedure in place which allows interested readers to replicate research based on proprietary or confidential datasets in principle, even if the raw dataset cannot be submitted to the journal due to juridical reasons.

In addition, a journal should have a replication section or publish positive and negative replications. Furthermore, journals should encourage their readers to use the replication section (if available) to conduct replications of previously published research. This will encourage authors to scrutinise their data; submission of poorly documented data or even junk will most likely be prevented.

Subsequently to the analyses of data policies, we also checked two other aspects: On the one hand, we analysed in which way journals provided research data and other materials to interested readers and possible replicators. For this purpose, we carefully examined both the websites and the data policies for hints on how these journals provide research data. On the other hand, we selected four issues of each journal equipped with a data availability policy and checked how many of the articles of each issue contain additional materials like datasets, code and descriptions of the data and the analyses.

3.1. Some Characteristics of the Sample

Based on this sketched approach, we were able to determine that 46.2% (160) of all journals in our sample primarily belong to the subject category of business studies and 38.2% (132) to economics. 9.8% (34) of all journals in our sample are open to submissions from both economics and business studies in equal parts. 5.8% (20) are primarily associated with other subject categories (for example psychology, mathematics or sociology).

When we had a look at the major publishers in our sample, we were able to determine the three biggest publishers in our sample: 19.7% (68) of all journals in our sample are published by Wiley-Blackwell, and the same percentage is published by Elsevier. In third place, Springer follows with 12.4% (43).

When we examined the statistical distribution of the journals in our sample, we noticed that the biggest group is rated with a 0.5 (mode) in the Handelsblatt ranking.

In total, more than 50% of all journals are among the three best-rated groups. Hence, better-rated journals are disproportionally represented. Nevertheless,

approximately 35% of the journals are among the three lower-rated groups. Moreover, 21 journals in our sample are not considered in the Handelsblatt ranking. The likely reason is that these journals do not appear important enough to be indexed. When we take these journals into account, the extent of lower-ranked journals in our sample is around 38%.

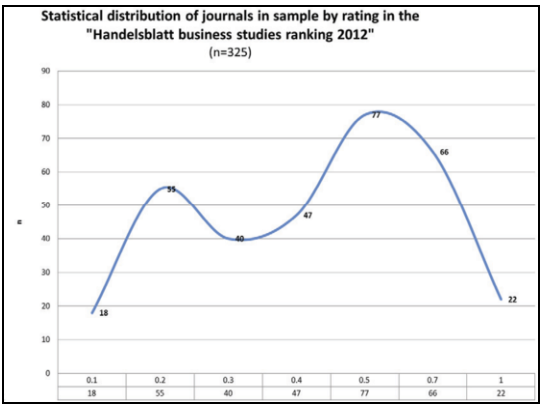

Figure 1. Statistical distribution of research sample in the Handelsblatt ranking 2012.

4. Findings of the Study

In the following paragraphs, we subsume the empirical findings of our study. First, we describe the outcome of the analyses on data policies, followed by results on current modes of journals in economic sciences to provide research data. To conclude, we appraise the degree in which journals enforce data availability by an investigation of the journals' data archives. We present the findings we obtained while checking four issues of each journal with regard to available research data.

4.1. Data Policies of Journals in Economic Sciences

Based on our approach described above, we were able to identify a total of 71 journals which have a data policy (20.5% of the total sample). 49 journals held a policy we classified as a data availability policy (14.2%).

Among the different subsamples (subject categories) of journals, we were able to determine important differences: 34 of the 49 journals belong to journals primarily publishing economics research (this equates to 25.8% of all economics journals in the sample), whereas only nine journals from the field of business studies have such policies (which equates to 5.6% of all business studies journals in the sample).

Another 22 journals (6.4% of the full sample) were equipped with a policy that relies on the author's willingness to provide research data (and sometimes code), even though some journals mandate their authors to do so.

Nevertheless, this latter type of policy does not work in practise: Feigenbaum and Levy [19] and Mirowski and Sklivas [20] have shown the disincentives for economists to participate in the replication of their work. Their theoretical work was underpinned

by McCullough's and Vinod's experiences when they tried to replicate all empirically based articles in a single issue of the American Economic Review (AER): "*Though the policy of the AER requires that "Details of computations sufficient to permit replication must be provided," we found that fully half of the authors would not honor the replication policy.*" [22].

Data sharing and helping to replicate one's own work does not comply with the common incentive schema. Therefore, such policies can be considered to be weak policies.

Among the remaining 49 journals equipped with a DAP, we found highs and lows. While some of the journals hold strong data availability policies, other policies merely appear to be window dressing: Only 61.2% of all data availability policies are mandatory. Against the background that data sharing is not widespread among economists – Andreoli-Versbach and Mueller-Langer found that roughly 2.5% of 488 applied economists regularly share their data [21] – and current practices on how to obtain credit in science do not incentivise documenting and sharing data, it is crucial to mandate the submission of underlying datasets and other materials.

77.6% (38) of all DAPs require the authors to provide the code of computation, 53% (26) also require researchers to submit self-compiled software components and another 71.4% (35) want their authors to provide descriptions of submitted datasets and other materials. While 69.4% (34) of all DAPs offer exemptions (e.g. for proprietary or confidential datasets) to the policy, another 24.5% (12) did not state whether such exemptions exist. Normally, such exemptions are granted by journals, so we conclude that 93.9% (46) of all journals with DAP seem to allow exemptions. On the other hand, only 52.2% (24) of these journals have a procedure, normally a requirement to post the code of computation in addition to other information like a contact address and the version and name of the dataset used, which would principally allow interested researchers to replicate even research based on proprietary or confidential datasets. This obviously is not a good result, because research based on such data is not replicable in almost every second case.

37 out of 49 journals (75.5%) with a data availability policy require their authors to provide the data and other materials with the initial submission or prior to publication – a good result. The editorial offices seem to have recognised the importance of the timely submission of data and associated materials.

Table 1. Requirements for data availability policies which facilitate replications (n=49)

criterion	yes	no	not stated
mandatory policies	30 (61.2%)	19 (38.8%)	-
code of computation	38 (77.6%)	-	11 (22.5%)
descriptions of data	35 (71.4%)	-	14 (28.6%)
self-compiled software	26 (53.1%)	-	23 (46.9%)
exemptions allowed	34 (69.4%)	3 (6.1%)*	12 (24.5%)
procedure for prop. data	24 (52.2%)**	-	22 (47.8%)**
public data disclosure	45 (91.8%)	1 (2%)	3 (6.1%)

* These journals "discouraged" the use of proprietary or confidential datasets.

** Due to three journals which discouraged the use of proprietary data, the sample size was reduced to 46.

Replications, in sharp contrast, are published by only five of the journals investigated, even though a few journals claimed to support the publication of replication studies (both positive and negative). Journals using Dataverse or similar software components offer readers the possibility to comment on data and code submitted and to give feedback on data quality and success or failure in replication attempts.

When examining some other characteristics of journals with data policies, we found that journals with DAPs are better rated than journals without such policies. 95.9% (47 out of 49) of journals with a DAP possess an Impact Factor, compared to only 57.2% (198 out of 346) for journals without any data policy. In the Handelsblatt ranking, journals with DAPs are rated 0.1 points better compared to journals with an ARP and to journals without any data policy (median). The same goes for the Impact Factor: Journals with DAPs are rated 0.63 points better than journals with an ARP and 0.69 points higher than journals without any data policy (median). Also, in the JOURQUAL ranking, journals with a DAP are rated 0.54 points better compared to journals without a data policy and 0.56 points better than those with ARPs (median). We also found more than three quarters of all journals with a DAP are among the three best-rated groups of journals in the Handelsblatt ranking.

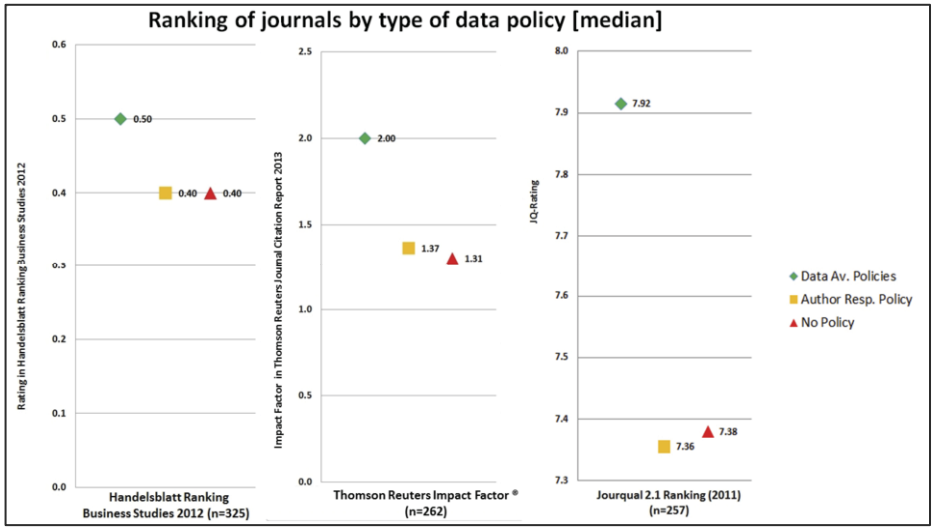

Figure 2. Ranking of journals in our sample by type of data policy (median).

4.2. Infrastructure Used for Journals' Data Archives

When we were able to find a DAP, we also checked in which mode research data and associated materials are made available for would-be replicators. On the one hand, we checked the content of the data policy, and on the other hand, we checked the journal websites to find out which infrastructure component is used to provide these additional materials.

Our findings suggest that most often research data is provided by the journals' websites: 83.7% of all journals with a DAP choose this mode to provide research data and other materials, 14.3% use special software for this purpose or suggest the use of external repositories to their authors.

Table 2. Provision mode for research data in journals equipped with a DAP (n=49; multiple modes possible)

Website	Author's Website	Repositories/ special software	No publication	Not stated
41 (83.7%)	2 (4.1%)	7 (14.3%)	3 (6.1%)	1 (2%)

The major problem in providing research data via websites from the viewpoint of scientific infrastructure providers is that there is no additional metadata for the supplements. Therefore, these datasets can neither be cited adequately, nor is it possible to reuse the datasets in any context other than the original article's – simply because these datasets are not findable. Though there are useful and easy to use solutions (e.g. Dataverse), only a small minority of journals in economic sciences apply these solutions: In total, only four journals with a DAP and a focus on economics research (i.e. 12.5% of all economics journals equipped with a DAP), and three with an 'other' classification (i.e. 60% of all 'other' journals with a DAP) used specialised software or employed external research data repositories. Not a single journal with a focus on business studies chose this way to provide readers with data and code of empirically based research.

4.3. Do Journals Enforce Data Availability?

In the course of our study, we also checked the data archives of all journals equipped with a data policy. We investigated four issues of each journal to determine how many articles are supplemented by research data and other materials.

The results we obtained suggest that data availability and replicable research are not among the top priorities of many of the journals surveyed. For instance, we found 10 journals (i.e. 20.4% of all journals with such policies) where not a single article was equipped with the underlying research data. But even beyond these journals, many editorial offices do not really enforce data availability: There was only a single journal (American Economic Journal: Applied Economics) which has data and code available for every article in the four issues.

5. Discussion

With the results we obtained, we are currently not able to determine a new publishing paradigm for journals in economic sciences. But there are differences among the subdomains of economic research: Especially economics journals with DAPs are slowly but steadily increasing: While McCullough [4] in 2009 was able to find only 10 journals equipped with such policies, Vlaeminck [12] was able to find a total of 29 journals with DAPs. Two years later, we identified 49 economics journals outfitted with such policies. These editorial offices seem to reflect the recommendations of scientific and political bodies to foster replicability of published research.

But we also found great discrepancies among the different subsamples in our sample: While journals focusing on economics research frequently have much more suitable data policies, DAPs are rare for journals in business studies. To explain these differences, we should keep in mind that research data in economics and business

studies is not identical. For instance, research data in business studies often consists of proprietary or even confidential data. Potentially the nature of this data leads the editorial offices of journals in business studies not to implement strong data policies, because they do not believe they would receive a noteworthy amount of data. Because developing and implementing data policies and related workflows is time and cost consuming, journals in business studies seem to be reluctant to enact such guidelines and processes.

Another assumption also provided true: In most cases, journals with strong DAPs are among the profession's top journals. Editors often mention that such journals can afford to implement such guidelines, because everyone would like to publish a paper in such a journal and is willing to submit datasets and other requested files, while a medium or low-ranked journal planning to implement a DAP could see a reduction in the amount of submissions it receives. However, we were able to identify a few lower-ranked journals which nevertheless are equipped with a strong data policy.

Relating to the requirements of the DAPs in our sample to foster replicable research, there is still room for improvements for many policies. The fact that a large portion of the guidelines are not mandatory is one such aspect. The failure to require self-compiled programs in many policies is another. Also, the absence of clear rules in cases in which proprietary data was used to obtain results in empirically based papers is an aspect that should be improved.

But even the best policy is meaningless if it is not enforced – and obviously many journals do not treat data availability as an important issue. With more than 20% of all journals in our sample clearly not putting their policies into action, there is a serious problem in terms of replicable research.

There are several aspects where research libraries and organisations dealing with research data might help publishers and editorial offices in lowering the burdens of implementing research data policies: One of these aspects is to advise editors how to develop suitable data policies. Another is to develop and to implement –powerful and lightweight software components which would reduce the cost and effort of managing data from empirically based articles. The fact that most journals still provide research data and other materials as a zip file on the publisher's or editor's website shows that there is an urgent need for such technical solutions.

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