



## Math in the Time of Coronavirus

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While many businesses experienced significant downturns during the pandemic, several scholarly publishers reported increases in submissions in the first part of 2020. There are various studies and articles about the phenomenon. Meanwhile, at Mathematical Reviews, we have not noticed a significant increase in the number of publications in mathematics during 2020. I should emphasize that many of the announcements and studies are counting *submissions*, while we count *publications*, which have a built-in delay of weeks or months or even, occasionally, years. In what follows, I look at some data about publications in mathematics in 2020, with comparisons to 2019. The data come from four sources: Dimensions, Web of Science, the Mathematical Reviews Database, and the arXiv.

Announcements about exceptional growth in submissions include: SpringerNature reporting an 11% increase in submissions in the first six months of 2020, Elsevier reporting 25% growth for submissions to their subscription journals from January to September, and Wiley reporting a 13% increase for their fiscal year 2020, which ended April 30, 2020. A large study by Squazzoni, Bravo, Grimaldo, Garcia-Costa, Farjam, and Mehmani [2] looked at hundreds of thousands of submissions to Elsevier journals between February and May in the three years 2018, 2019, and 2020.

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They found that the number of submissions to all Elsevier journals in February–May 2020 increased 58% over the number of submissions in the comparable four-month period in 2019. For health and medicine journals, the increase was 92%. Their paper did not address submission rates in mathematics.

In a pair of posts to The Scholarly Kitchen [3,4], Christos Petrou compared the growth rate in 2020 with the Compound Annual Growth Rate (CAGR) in the period 2013 to 2019, using data from Dimensions restricted to the curated ERA-2018 (Excellence in Research for Australia-2018) list of journals from the Australian Research Council. The updated result in his second post is that there was an increase of 8% from 2019 to 2020, as compared to a CAGR of 3% over the previous six years. For comparison, the growth in 2018 was 4.1% and in 2019 it was 4.6%. When Petrou removed articles that contained the word “covid” in the title or abstract, the growth for 2020 was just below 5%, which is roughly in line with the increasing growth of the previous two years.

### Growth in Publications in Mathematics

#### Dimensions

Dimensions [1] is a knowledge and information system from Digital Science that includes a database of publications. I used it to search the journals in the Australian ERA-2018 list within the research field of Mathematical Sciences. This collection has a 2013–2019 CAGR of 2.3%. The growth rate for 2020 was 7.9%. While this is high, the rate for 2019 was 7.0%, and for 2018 it was 6.1%. Comparing the growth for 2020 to the six-year CAGR is a bit awkward because the

growth rates in the years 2015, 2016, and 2017 were 0.9%, -1.1%, and 0.5%, significantly reducing the CAGR. Thus, while 2020 looks like an anomaly compared to the compound rate, the same could be said about 2018 and 2019.

**Web of Science**

For the Web of Science, I restricted the search to their Science Citation Index Expanded collection. The search looked for document type = Article and subject area = mathematics. The year 2020 is somewhat remarkable, but 2019 is even more so. In particular, there is no indication of an increase during the pandemic. The data are in the following table.

Year	Web of Science: Math	Growth
2010	48,596	-1.3%
2011	51,300	5.6%
2012	54,570	6.4%
2013	57,428	5.2%
2014	58,719	2.2%
2015	58,087	-1.1%
2016	57,846	-0.4%
2017	60,335	4.3%
2018	62,063	2.9%
2019	69,573	12.1%
2020	75,826	9.0%

Data from Web of Science SCI Expanded.

**Mathematical Reviews data**

At Mathematical Reviews, we receive journal articles, conference proceedings, and books in various ways. Some are delivered to us electronically by the publishers. Some we retrieve electronically. Some are still delivered as printed copies. Our operations were interrupted by the pandemic. Therefore, including the counts of papers we retrieved, processed, and posted to MathSciNet would more reflect what was happening at Math Reviews than what was happening with publications. Therefore, I want to focus on the counts of journal articles being delivered to Mathematical Reviews by the publishers. I only have consistent data for these counts starting in 2017. Figure 1 shows a graph of the counts by quarter from 2017 to 2020. It is evident from the graph that there were no extraordinary increases in 2020.

**arXiv data**

Finally, let's look at some data from the arXiv. One benefit of these data is that we can count *submissions*, rather than just *publications*. The arXiv is quite generous about making their data available. (See <https://arxiv.org/help/stats>.)

Looking at all subjects in the arXiv, the growth in submissions has clearly been consistent over the years and is well approximated by exponential growth at a rate of about 8.5% from 2000 to 2020. There are at least two confounding factors, though. First, over the years, the subjects covered by the arXiv have expanded. Second, within subjects, adoption of the arXiv has increased over time. Even so, looking at the annual data since 2010, it does not seem that 2020 was extraordinary. Indeed, the growth rate

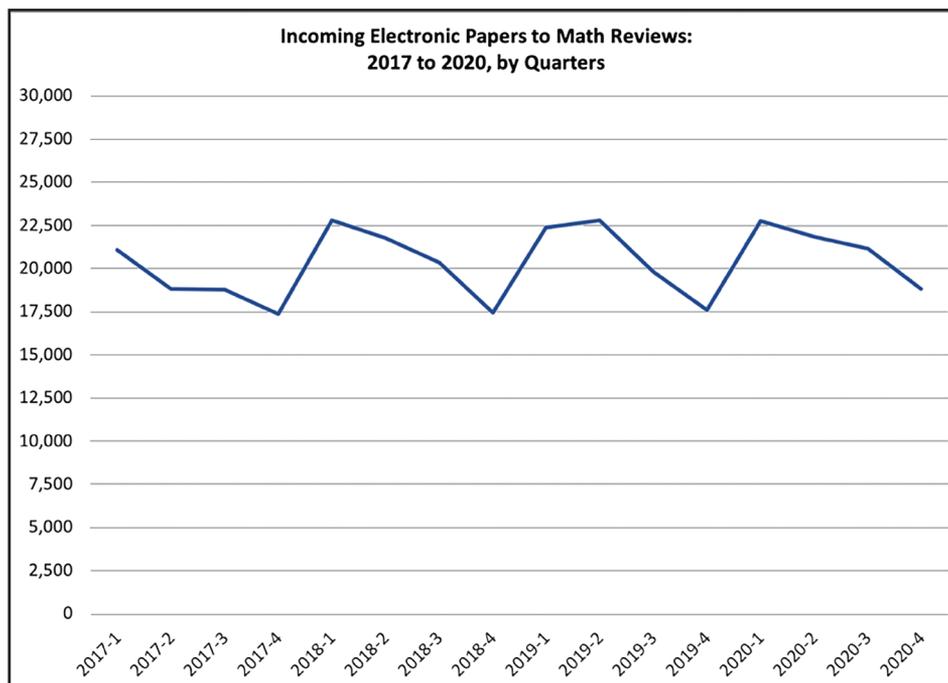
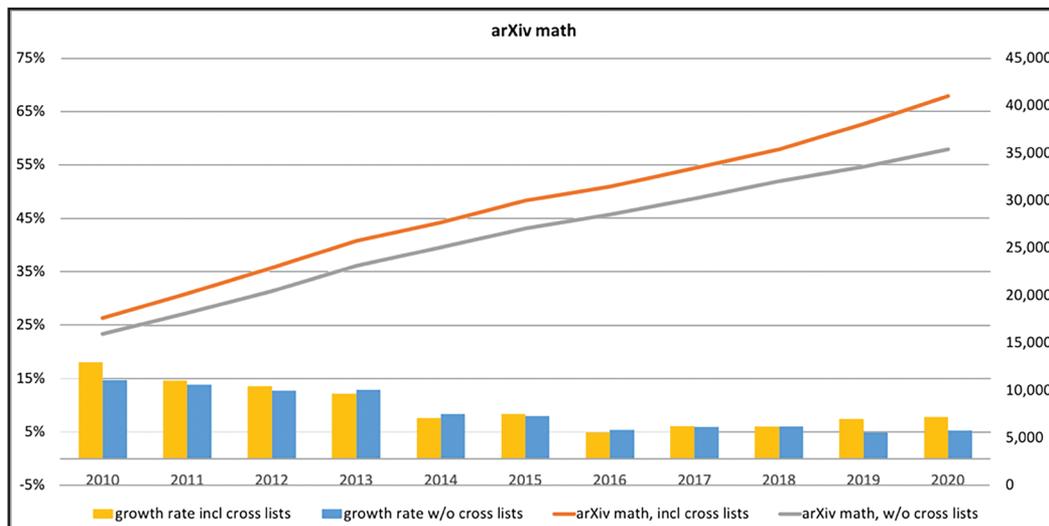


Figure 1.



**Figure 2.** Submissions by year to the arXiv in mathematics, with and without cross-listings. The bar graph gives the growth rates; the lines represent the counts.

in 2020 of 14.4% was roughly the same as the growth rate in 2018, which was 13.8%. The growth in 2019 was 10.8%.

**arXiv data: Mathematics**

The data for submissions in mathematics to the arXiv from 2010 to 2013 seem to demonstrate one of the confounding factors: increased adoption. Figure 2 shows growth rates and annual submissions in mathematics. Counts and rates are given for all math submissions, including cross-listings in other subjects, and for submissions that are only in math, with no cross-listing. From 2001 to 2009, the growth rates of math submissions in either category were mostly high, between 15% and 28%, with two years around 7% and the year 2002 over 30%. In the years from 2010 to 2014, the growth rates of submissions were between 12% and 18%, at the tail end of the increased adoption period. By 2016,

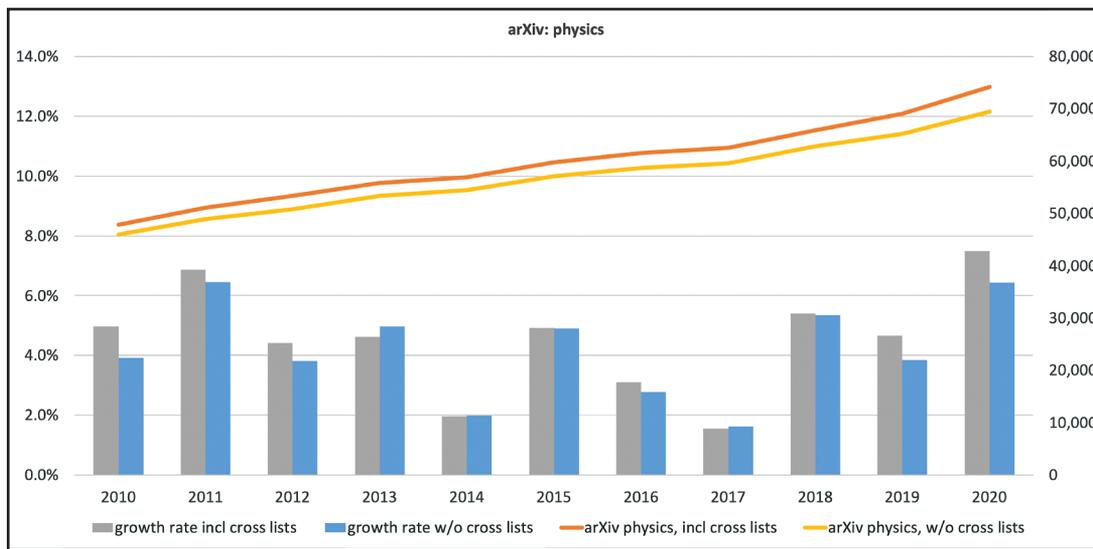
this stabilized to rates between 5% and 8%. In any case, the annual data for 2020 do not look anomalous.

**arXiv data: Physics**

For comparison, I looked at similar data for physics in the arXiv. The growth rates for physics submissions to the arXiv in 2020, both with and without cross-listings, were certainly higher than in recent years, and greater than the CAGRs for the two categories. The growth rate for physics in the arXiv has a lot of variation, though, making it unclear whether 2020 was an exceptional year or just a very good year.

**arXiv monthly data**

I also looked at monthly submission rates for mathematics and for physics from 2018 to 2020. There are peaks and valleys in the monthly data, with both mathematics and



**Figure 3.** Submissions by year to the arXiv in physics, with and without cross-listings. The bar graph gives the growth rates; the lines represent the counts.

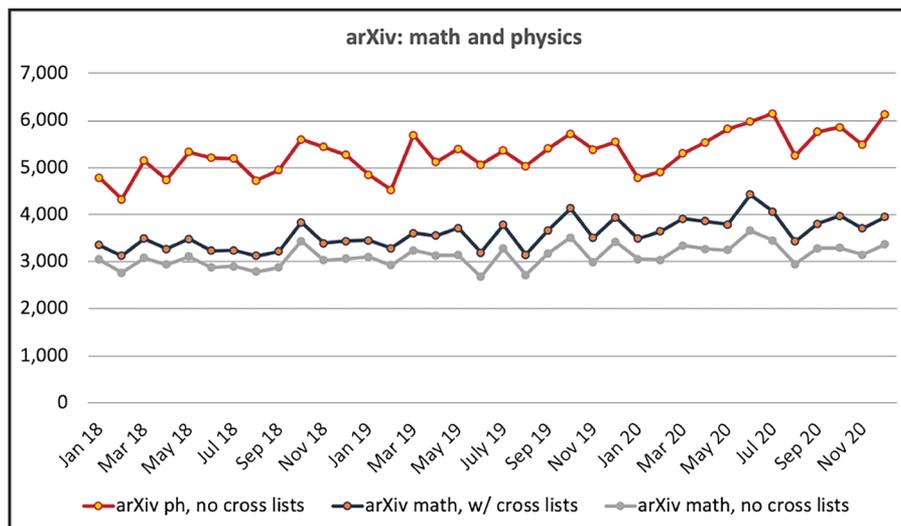


Figure 4. Monthly submissions to the arXiv in mathematics and physics.

physics having peaks around June–July 2020. For physics, there was unusually steady growth from February to July 2020. For mathematics, the June 2020 submissions were up 12.8% over the May 2020 submissions, and up 16.9% if cross-postings are included. The submission growth in the two months before and the two months after June, however, were much lower than in other months. Also, since January 2018, there were four other months with greater increases for mathematics, including jumps of 19.4% in October 2018 and 22.1% in July 2019 in mathematics without cross-postings, and 19.5% and 18.3% with cross-postings. This jump is certainly unusual, but it would be odd for a protracted pandemic to spur a lone month of increased growth in submissions.

## Conclusions

Unlike lab-based sciences, there does not seem to have been an unusual growth in articles being published or posted to the arXiv in mathematics in 2020, other than a single month for the arXiv. One hypothesis mentioned in the various studies mentioned above is that with many scientists unable to work in their laboratories, they are finding time to write papers. This seems plausible, and would also explain why most mathematicians are not finding so much extra time to be writing papers during the pandemic.

## Remarks

There are more charts and data in my blog post [5]. Much of this column discusses changes in growth rates, that is, second derivatives.

## References

- [1] Dimensions, <https://app.dimensions.ai/discover/publication>.
- [2] Flaminio Squazzoni, Giangiacomo Bravo, Francisco Grimaldo, Daniel Garcia-Costa, Mike Farjam, and Bahar Mehmani, *Only second-class tickets for women in the*

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- [3] Christos Petrou, *Scientific output in the year of COVID*, The Scholarly Kitchen, Society for Scholarly Publishing blog, November 19, 2020. <https://scholarlykitchen.sspnet.org/2020/11/19/guest-post-scientific-output-in-the-year-of-covid/>.
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- [5] Edward Dunne, *Math in the time of coronavirus*, <https://blogs.ams.org/beyondreviews/2021/01/19/math-in-the-time-of-coronavirus/>.



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