

Introduction

Students, teachers, researchers and the public require comprehensive access to academic information and literature. Today, almost all literature, printed or digital is discovered online, in library catalogues, search engines, dedicated academic discovery services, and many new forms to come. The cases of allegedly manipulating elections by placing information in the social web shows at least two directions of what we have to expect in the future of the discovery of information: First, that we will face completely new, complex, subtle forms of discovering academic information. Second, that we will require ever more access to information to be able to educate specialists and society at large to understand how to maximally benefit from the world of knowledge and be able to critically assess it.

In which future the discovery of academic information will develop is almost impossible to predict. The following text will, however, provide several possible – at least thinkable – scenarios, including extreme cases, such as the upload of a human mind into the digital sphere. Some of these scenarios are utopian, some are dystopian - but all are based on technology for research which is in development at the moment, and are intended to provoke thought about the implications of the technology. The scenarios are written as short science fictional narratives and will not provide background information, explanation or discussion – they are rather thought as an inspiration to think outside the box. Further reading is listed for each scenario, but again, this is reading designed to provide fuel for the imagination rather than the standard style of reference for readers who want to investigate further. The overall purpose is to inspire interest in and thought about the future of discovery - and thus there seems to be no better way to end this book.

As an introduction – before the scenarios will be presented – two possible directions in the future world of academic information shall be contrasted: one showing an open and transparent world of knowledge, the other a restricted and undisclosed. Both seem to be possible outcomes of current trends in the world of academic research information, and these two extremes are presented to show just how different the future of research can be - and the future of the discoverability of research can be, in particular - depending on the outcome. By demonstrating the width of the difference between two very plausible scenarios, this section not only says something about the future of research and discovery, but also acts as a warning that the scenarios which follow are not to be taken as predictions. They can at most be possibilities.

We need to give a small procedural warning before you continue reading. The scenarios are presented in a mixture of first and third person narration, and this is deliberate. The purpose is to give either a more personal, first person, narration, as though the reader is being told something over a coffee or is reading a blog, or an apparently more formal, closed and impersonal narrative, as though the reader has access to a report. The narrative forms chosen felt to the writers to be the best fits for what they wanted to say in each scenario.

Possible characteristics of an open future of academic research and information

1. The public domain of scientific information is considered as international law. Open Access is the predominant form of publication.

2. Academic information services work smoothly across borders, legally, organizationally and technically.
3. Research data complies with FAIR principles: Findable, Accessible, Interoperable, Reusable
4. Sophisticated authoring and assessment tools allow researchers to dynamically and autonomously publish all research results.
5. There is a global, freely accessible corpus of all scientific citations and usage data.
6. Scientific impact is no longer measured by publications and citations alone.
7. Reproducibility of research becomes so important that deception and plagiarism disappear.
8. The boundaries between scientific expertise and general knowledge, such as in Wikipedia, dissolve.
9. Scientific hypothesis formation is supported by machine learning.
10. Start-ups on innovative forms of science communication and economic exploitation of scientific results grow on the grounds of public domain data.
11. Digital skills are an essential part of scientific education. New degrees and scientific professions for digital science emerge. Data Science is an independent discipline.
12. By attributing academic digital services the same importance as buildings in budget planning, a sustainable, public global infrastructure is operative.
13. High-performance digital libraries are created to distill all scientific information into the cultural heritage of the future.

Possible characteristics of a closed future of academic research and information

- I. For scientific publications, publishers impose high fees as they are being created, and the cost of licensing magazines and eBooks is growing at an unprecedented rate.
- II. There is only one single commercial platform for publishing scientific results and a single citation database decides on the evaluation of any scientific achievement.
- III. Deception and plagiarism in the digital world are increasing in numbers to meet the increased demands on rating systems.
- IV. Digital research data is massively lost or disappears behind barriers to economic exploitation - publishers sell the research data back to universities and research institutions.
- V. The reproducibility of research using digital methods is worse than that of analogue research.
- VI. The value of research for the economy and for the societal and political legitimacy is dwindling.
- VII. General knowledge on the Internet is increasingly distorted and manipulative.
- VIII. There is a massive shortage of digital skills in science - digitally savvy researchers and the next generation migrate across countries.
- IX. The interests of science is officially declared to be of inferior importance than economic growth. Academic freedom disappears as constitutional right.
- X. International law recognizes that public domain content may be licensed and may be withdrawn from public access.
- XI. Public budgets cannot justify the power consumption of institutional data centers, otherwise the cost will severely limit the quality of study.
- XII. Large parts of the scientific information infrastructure are provided centrally by a single company.

Scenarios

Universal Open Access

Philip K. finds a recently deceased darkling beetle in the Namib desert. He stops his exploration of the dunes and puts a physical sample from his abdomen in his mobile analytics device. He tags the spectroscopic analysis process with the species name and geo-coordinates. The result display shows the organic and chemical composition of the sample, alongside choices of scientific literature relating to the beetle, vegetation and geology in the area as well as biomechanical and engineering research that relate to the beetle's ability to produce water from fog that it gathers on his back. Philip is actually a meteorologist. To find clues about the origin of the water in the body of the animal, he enhances the spectroscopy to give clues about its composition. Literature about water and air composition in the area appears and a suggestion to upload the results of his sample to a data collection. "Thank you for sharing your data" the display reads "Your sample has now been added to the database and linked to 13.456 scientific articles." Philip is briefly thinking about the speed and efficiency of connecting scientific publications among each other and with research datasets since all research worldwide became open access. The display shows another message: "Another dataset has been uploaded less than 10 km from your location." Philip looks at the dataset and recognizes the name of a Namibian colleague as author. "Contact!" he speaks into the device "Dinner tonight?"

Further reading on the future of open access:

Faye Chadwell and Shan C. Sutton discuss the changing role of the librarian in the next twenty years of a world where Open Access becomes the norm and where librarians have a very different role in academic life (Chadwell & Sutton, 2014). Meanwhile, Richard Poynder surveys where things are now, and how the current Open Access landscape differs from the expectations and ideals posited by its advocates (Poynder, 2018) - a warning for how the future may differ from the hopes of librarians planning for it now.

Run my Thesis

The magic of using executable document tools from the start of my PhD is that I now have an executable thesis. This has made it a lot easier for me to perfect the science—as new data has come in I've been able to rerun and adapt the work. And as the thesis ideas developed in my head, I was able to incorporate them, hook the new text into the execution layer, and make sure it was firmly based on the data. I'm confident in the work I did, and the software underlying it - and what's more I know it's reproducible. My supervisor said it was the same for her generation when they first got their hands on digital tools—early on it feels like extra effort, but once you're doing it you get the benefits pretty quickly: the old jupyter notebooks took off rapidly once researchers heard of them. I wouldn't work any other way now.

Next step is the viva, when my examiners will have run the thesis for themselves—not so much *viva voce*, more *per machina*. And then it goes in the executable library, and everyone can use it.

My colleague finished her PhD last year. She generated two new papers recently just by rerunning the thesis when she was notified of new data, which was great. But one of her friends wasn't so lucky—his thesis broke about 6 months after deposit. The data hooks still seem to be good, which is so frustrating, but the executable format is no longer compatible with the libraries on his institutional repository. Good thing my institution can afford the latest release of the autonomic software. Digital preservation is still an issue! Maybe one day the AI managing the library will get a bit better and the reproducibility robots will repair things. If that happens, the thesis can be re-run with the latest data, but for now, it is at least still possible to look at the ideas and conclusions from the data up until last January: back to the old world of fixed documents.

Further reading on executable documents:

Project Jupyter¹ aims to produce open source software, standards and tools for interactive computing, including a Notebook application to allow you “to create and share documents that contain live code, equations, visualizations and narrative text”. More theoretically, (Strijkers et al, 2011) discusses an executable paper concept aimed at improving reproduction and validation of computationally obtained results in scientific papers, and (Montagano, 2018) looks at the possibilities for research articles beyond the PDF format almost universal today.

Uploaded Minds

Professor Anna Ng began her next task, catching up with the particle physics research literature. There were rumours yesterday that CERN were about to formally announce the confirmation that abnormal fragments from collisions in the Large Hadron Collider II conformed to one of the theories which extended the current version of the Standard Model. Her feed reader showed a new item, which was the expected news, with attached datasheets.

Immediately, she began to try to understand this new information, hooking part of her consciousness up to one of the physics department's data processing machines, while simultaneously looking up how the new announcement changed the relationships in the reference management system, and reading the suggested relevant papers.

Anna was able to see a three dimensional animated model of the collisions, and work through them in ultra slow motion and ultra high resolution. She could see the yellow tags embedded by CERN researchers to mark features of interest, and the new green ones which were being added by research physicists around the world as they worked on it. Taking this data and adding the tags to her personal reference management system showed new connections, converging

¹ <http://jupyter.org/>

to an obscure paper from arXiv, one which had been written but abandoned without publication when its theoretical models had failed to materialise. Success! She appeared to be the first researcher to make the connection! The unique nature of her reference management, and the order of the import of the tags had given her a temporary advantage over other physicists across the world.

Assimilating the paper, noting that it was nine years since it had been read, she added a tag with a link to it at the crucial point in the collision model. Her ethical duty to the principle of shared scholarship done, she was able to relax and begin thinking about the implications, trying to formulate a modified Standard Model extension which would incorporate this paper and the new data. But even now she continued to communicate with the rest of the theoretical particle research community, as well as upgrading her Lie Algebra representation theory knowledge to incorporate the latest ideas. As this helper module loaded into her mind, she was able to see the flaw in the current version of the extension, and began to rebuild it, now acting as part of the University theory group as they pooled their knowledge. She did have time for an off-topic thought, that things had changed so much since this would have taken days of labour with discovery tools with their limited two dimensional lists of results, discussions and emails with colleagues, and, above all, coffee. Things were so much better for the onward march of science now that she had abandoned her physical body for the upload to the University research infrastructure, now that she could work as fast as their latest processors could manage, and now that anything on the Internet was just a thought away. Even for her new way of living, this work was going to take a long time; already she had spent five whole minutes on it.

Further reading on uploaded minds:

Based on an episode of the BBC's *Horizon* science magazine programme, (Quinn, 2016) discusses immortality through uploading with quotes from Russian millionaire and advocate Dmitry Itskov, while (Jones, 2016) is more sceptical. A discussion of the philosophical background to the topic is given in (Hauskeller, 2012).

Doing Without my Virtual Assistants: Blog Post 1 from Charlie D.

I am one of a group of young cultural historians working on the 1980s who are taking part in, and blogging, a research project. Over the next week, we will be embedding ourselves in culture before the arrival of the virtual assistant. Apart from the connection to the blog, we will only use technology available before 1989. We believe that only by doing this can we properly understand the decade.

I have just said the words which start the experiment. "Danni, start the live blog session. Now ignore what I say for the next eight hours." Now I am what they used to call "logged out".

The plan is for me to do some research reading (on actual paper!), use an analogue telephone to order a pizza the old fashioned way, and write a letter, which was still common back then. The day will end with a departmental seminar to discuss the experiment - and we will actually all be physically present!

My first problem is working out what to read. Danni usually makes suggestions based on my notes on the reading I've already done, and she can't do that, and I'm limited to the physical reading material in the campus library. Yes, there was a time when this was the only way to obtain research material. The project had used some of its budget to pay Mrs Culver (she insisted on the old fashioned manner of address) to work with us. She is a retired librarian who had been working in the eighties. In those times, librarians acted as the gateways to knowledge.

So I tell her what I had read last week, and ask if she had any recommendations. Her response is strange: it was not her role to tell research staff what to do, she was there to make it possible for them to do what they wanted. This, then, will be my first big challenge: to organise my own research - Danni's job. I obviously have some idea of what I had read, but I couldn't list exact titles or anything like that. After thinking for a bit, I ask if she can find anything on the impact of computers on everyday life. After all, computers had been around for decades, there must be something I could read about how they were viewed in the eighties. Was there a famous study?

She leads me to a battered piece of furniture. "All the information you need is in here." I know eighties computers were big, but this did not look like a computer. No screen, nothing but wooden drawers full of small cards. "There are a couple of books by Alvin Toffler which you should read." This is almost like Danni giving me a list of what to read next!

"The cards are sorted alphabetically...look at T for Toffler, not A! Then the cards will tell you where to find the books." I shuffle through a few cards; this seemed easy enough. There are two for Toffler: Future Shock and The Third Wave. On the Future Shock card it said, "HN17.5.TOF". I ask, "Is that a DOI?" Apparently, it's something called a "shelf mark", and makes it possible to find items in a physical library. The shelves have plaques on them with part of the shelf mark, and you walk around until you find the aisle which has the ones you want, then the book is somewhere in that aisle. A lot more effort than clicking on a link! And the amount of work to find it was enormous: how did anyone ever get any research done, back in the day?

Further reading on virtual assistants:

While not specifically about virtual assistants, the impact of technological change is the theme of the classic book mentioned in this scenario (Toffler, 1970), and digital assistants are likely to cause huge changes in how we relate to IT. Like the other topics in this chapter, virtual assistants have proponents, such as (Brauer, 2014; Leetaru., n.d.), and sceptics, including (Gonzalez, 2017).

It can only be found what is there

It is a big day for Academic Journal Portfolio Analyst Mark T., entering the HQ of K.N.O. Publishing to present his new ideas on exploiting the publisher's search engine to the CEO. It's a general search engine that also includes journals that are not owned by them. It had started

as a mechanism to inform K.N.O.'s journal acquisition strategy, analyzing the whole world's research literature to identify journals that are strong and trending, using a machine learning algorithm that detected hot topics in the world of research. If the algorithm detected the field of, say, solar energy panels as a trend, K.N.O. started to acquire or develop the top journal in the field. This meant that researchers looking for articles about solar energy panels were likely to be directed to articles owned by K.N.O.

This has now led to criticism by academics because the search engine was suspected of favoring the publisher's own journal titles over foreign journal titles by putting them on top of the list of search results or highlighting them. "Academics are suspicious.", Mark begins his speech. "They will detect the finest adjustments in ranking that are not complying with the principles of academic disinterestedness. Several attempts to rank journals that we own higher than journals that we don't own have failed. And this had detrimental effects on the reputation of the whole search engine, which, in turn, also harmed the usage and value of the journals that we own. We need to apply supposedly neutral measures for the ranking -- such as citations. And we do. We already have achieved the position of the market leader by buying as many of the highly-cited journals as we could. But now this development strategy is stuck because the residual competitive journals are in the hands of other publishers and too expensive to buy or otherwise not available. But there is a possibility that might help us to marginalize those competitive journals and secure our market leader position.

Now, how can we make use our analysis of research trends to secure our position? The software has been used for many years for informing our purchasing. Thus, our market position is based on the category system that we use. Take the example of climate research. There is an innovative but controversial research paradigm in glacier research that is mainly published in "Glacier Theory". The main journal in the field is "Journal of Glacier Research". We acquired the latter because it is the largest in the field of glacier research and we did not buy the former: "Glacier Theory" never appeared to be on top in any category and, thus was never a priority object for acquisition. It is categorized under Geophysics, which, as a field, has other top-ranking journals that we already own. In general, we can only be as successful as our category system for research topics is. This is a risk for us.

What we need to do is to use our categories to define what is a research trend and what is not, rather than reacting to the emergence of trends. My proposal to do this is rather simple: we sell the research trends software to the leadership of universities and other research organisations to help them developing their institutional strategy. If an institution was to analyze its profile and, based on our research trends software, came to the conclusion that they should invest in climate research because big funding programs have recently been established there, they would seek to recruit in that field. If they now look for a professor working on glaciers, our research trends software will guide them to the researchers that perform best in both geophysics and climate research. These researchers are likely to publish in our journals and not in "Glacier Theory". When the same is happening in many institutions around the world, this would reduce the ranking of "Glacier Research" and, eventually, could render it obsolete. As a bonus, we gain new profits by entering the sector of research trends with very little investment because we already have the software. All we need to do is to invest a little in user experience design and establish a sales team that specialized on institutional leadership. Actually, we could re-train our sales teams for libraries since the library market is saturated. For us, it will be a zero-sum game."

The CEO sits back and exhales. He has listened very carefully. After a while of silence he comes forward: “Little investment and optimal use of existing resources: good. What about risks? What if this approach was seen as an attempt of manipulating institutional research strategies, similar to what we had with the boosting of search results?”

“This risk is very low” Mark replies “because the categorization is not the main product to be sold. Institutional leadership does not have the time and expertise to assess deal with the philosophical question of how to categorize research fields. It is mainly interested in seeing strengths and weaknesses of their institution. Scrutiny, if any, will be focused on how the research trends are being computed. And this method is transparent and robust.”

“And what if the algorithms constructing our category system were incorrect? It would mean that we steer global research to work in the wrong direction, correct? What if the controversial people publishing in Glacier Theory were right about the causes of climate change?”

“The algorithm that defines our category system has been developed by the leading researchers in the world. In other words, research itself does not have any better way to categorize knowledge.”

Further reading on algorithm ethics:

Ethics is an important topic in artificial intelligence. Some recent less technical discussions include (Anon, 2017), (Mancha and Ali, 2017) and (Beall, 2018).

Snakes and Ladders

I was on the way to the interview, glad to see a notification that my last article had just been cited only last night—just in time for today. It seems crazy that not so long ago people used to print out their list of publications to submit with their application. Today’s panel will use my citation graph and stats live in the interview. I wonder who cited me... Must remember to cite them back.

Waiting with the others to be called in for the interview, I take a closer look. Actually this is better than I thought—I’ve been linked into a really strong chain and it’s pulled me up a notch. Even my Erdős Quotient is up by 0.01. And I can see more and more readers coming to the paper as we speak, the paper title flickering with darker hotspots.

I go in and the graph is up on the wall. Neat—they’re using an animation showing it growing over time. Where’s the new citation? Out of the corner of my eye I see a fragment greying out on the far edge but can’t see what that is.

“Good morning. We have been modelling your outputs and projecting over the next 5 years. Could you talk us through your strategy around the outputs on the bottom right here?”

Outside the room, the next candidate put their device away. There's nothing like activating the strategic contracting bots once you've spotted the opposition.

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Further reading/viewing on manipulation of bibliometrics/clickbots:

As promised, *Nosedive* is given a credit (Wright, 2016). Interesting discussions include (Rice, 2012), (López-Cozar et al, 2014), and (Neophytou, 2015).

Data Tripper

In the old days we had some good reputable archives of data and they told you exactly what they were and how to use them. That was more straightforward. Then we had the 'frontier society' of the new millennium with data everywhere, and the big problem was finding what we needed. In fact, it was knowing what it was we really had. These were dark days of data-centric research, especially in terms of the archive we left behind.

My favourite web site (why do we still call them that?) used to be Data Tripper, especially when it all became about data streams rather than data archives. We used to rate data sources and see what everyone else thought of them, and the sources would do anything to get good ratings, encouraging us to review positively. Users meant credits and credits meant funding for the approved suppliers. Plus there was eBay for buying old datasets.

To an extent this helped us avoid the dis-data that was poisoning the ecosystem, and the side effects of the illegal data trade. But the more data that was out there, the easier it was to find the data for the results you wanted. The appetite for results had overcome the appetite for truth.

Automation has helped a lot, and it was essential because it was the only way to deal with the flood of data supply. People, and machines, are now taking provenance seriously in the ecosystem, so at least we know where everything comes from, and trust is that much better with crypto-distribution behind the scenes.

But now it's *all* automated I don't think we really know what it is we have. Who, or what, made the decisions and why? What is real any more?

Further reading on future/automated data curation:

Two discussions on automated curation are (Ismail, 2018) and (Wade, 2018).

Robots Take Over Research

Software and Research News

Lawsuit Over - Robots Can Research Too

By our AI correspondent, 2042-02-15

In a landmark decision, the US Supreme Court ruled last night that an artificial mind can be considered a creator of a PhD thesis, in a majority decision.

In 2035, psychology student Pat Schmidt submitted her thesis to the University of Northeast Michigan for her doctorate, not expecting to launch a lawsuit from A-Z Corps, who had developed the iJung digital assistants for psychology research. Ms Schmidt used a number of eJung modules, including the RJung research management tool and the wJung writing assistant. Her faculty adviser, Dr John Pellew, alerted the University to a possible case of cheating when he thought he detected that large parts of the thesis were not written in the manner he expected from Ms Schmidt. Dr Pellew, who died last year, commented when giving evidence as a witness, "Even when there is a suspicion that work is not original, it is vital to take it further. But in this case, several sections of the thesis were clearly not written by the same person as the rest of it."

Digital analysis software agreed, and Ms Schmidt was told that her thesis could not be accepted. The next day, 25 May 2035, her lawyer served a writ on the University. In it, the claim was made that the portions of her thesis - estimated at between 35 and 50% - which did not match Ms Schmidt's personal writing style, had been composed by eJung, which was a permitted writing and research aid. The University's lawyers countered by pointing out that the extreme level of use amounted to a collaboration rather than assistance, and that collaboration on a Ph.D. thesis was not permitted.

This argument gained notoriety, and was the third fastest trending story of 2035 (after the British royal divorce and the Hollywood Walk of Fame murders). Interest died down as much of the case consisted of lengthy technical arguments, ironically produced in the main by artificial legal expert systems, conducted at a speed impossible to human advocates. Last night's ruling, by a majority of 6 to 3 justices, is widely expected by commentators to open the door to the acknowledgement of the role played by digital assistants and artificial intelligence in modern life.

Long time AI guru Maya Ingold, who was several times consulted as an expert witness, feels that this is inevitable. “Over the last thirty five years, since the early pioneering efforts of Siri, Cortana and Alexa, digital assistants have woven themselves into every part of our lives, from designing the perfect breakfast menu, to setting the optimal time to retire for the night. Since the first successful newsfeed produced without human intervention was unveiled in 2021, artificial intelligence has been taking on tasks previously thought to be the sole province of human minds at an increasing rate. While AI has helped in research for decades, it has until now seemed that the spark of manual intervention was needed to produce a creative new piece of research. That final bastion has now fallen, and it is only a matter of time - perhaps only a short time - before all research work is carried out by machines.”

An opposing view was held by Professor Zachary Post, who has spent years campaigning for what he calls “real work for real people”. To him, the advance of the machines is more a retreat from humanity. “Since before the dawn of recorded history, the unique mark of the human species has been its questioning mind. We have come a long way since we were hunter gatherers, but every new technological advance has had its downside. This ruling, though, is taking things too far. We must stop our slide into dependency on machines. I call on all of you to turn off your assistants, to go back to finding your own way through life. Be inspired, be inspirational, and, above all, be human”.

Who will prove to be right? This reporter is not able to decide, but as an electronic entity myself, I will fight to stay connected and not be switched off.

Further reading on AI creativity/journalism:

Creativity is another hot topic in artificial intelligence. A general article can be seen in (Anon, 2015) while (Hall, 2018) and (Underwood, 2017) both discuss computer journalism.

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Editorial Afterword

...to the chapter...

This final chapter is, as I and the other authors hope, a fun but thought provoking way to end a book on discovery. Some of the ideas in this chapter may seem outlandish, but even as we were writing them, we could see them resonate with current news stories (the coverage of Alexa laughing² could almost have been another scenario, and there always seem to be stories about manipulating fake news³ and chatbots being led astray by human beings⁴ - or taking jobs away from them⁵). Discovery is already changing fast, and the research and learning it underpins is also rapidly developing.

...and to the book

Discovery and the underlying data which supports it are closely allied, and the forms of the objects to be discovered are also important. While some of the scenarios in this chapter may seem to be more about the evolution of research practice, such changes would have an immense effect on how the outputs of research are discovered. Recent suggestions on replacements for the academic paper (Somers, 2018 and Andrus, 2018, among others) suggest that a more fluid, nuanced, multimedia - or even executable - format for scholarly communication will become prevalent. This clearly would not fit well with today's static indexes in bibliographic databases mechanisms for discovery: how would services need to change to keep up? Are artificially intelligent curation and personal discovery bots the answer? Or will future discovery use something else, not yet thought up?

As editor, working on this book has brought home to me even more just how important discovery is to teaching, learning and research, and thus how key the development of discovery

² <http://www.bbc.co.uk/news/technology-43325230> from March 2018

³ <http://www.bbc.co.uk/news/av/world-43472347/cambridge-analytica-planted-fake-news> from March 2018

⁴ <http://www.bbc.co.uk/news/world-asia-china-40815024> from August 2017

⁵ <http://www.bbc.co.uk/news/business-43259906> an opinion piece from August 2017

services is to the future of academic endeavour. Perhaps because of my role as a facilitator of discovery services I am biased, but it does seem to me that resource discovery is the purpose of existence for libraries today: there is no point to a library if its contents (and, nowadays, subscribed resources) are unable to be found by students and researchers.

It is an exciting and challenging time to be working in this field - and the one thing which is certain is that it will not stop being either for a while to come.

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