Charting the digital transformation of science
Findings from the new OECD International Survey of Scientific Authors

Digital technologies today are transforming every aspect of scientific research. This digital transformation has raised important issues for policy makers, as governments look to leverage new technologies to stimulate innovation and efficiencies in science, and to address pressing policy challenges. Results from the latest edition of the OECD International Survey of Scientific Authors (ISSA) – drawing on the views of nearly 12,000 scholars – reveal important insights into the ways in which digitalisation is changing scientific research, and how policy makers can maximise its benefits while addressing the challenges that arise from the widespread adoption of new digital tools and practices.

The many faces of the digitalisation of science

The scholars surveyed in the latest ISSA represent corresponding authors of indexed articles and conference proceedings published in 2017. An analysis of their responses to a broad set of questions identifies four distinct facets of digitalisation in scientific research:

- the adoption of digital scientific collaboration and productivity tools throughout the different stages of the scientific process
- digitally enabled diffusion of, and access to, data and code
- the use of advanced and data-intensive digital tools to gain insights and develop predictions
- the development of digital identities and online communication of scientific work.

Figure 1. Patterns of digitalisation in science, by scientists’ country of residence

Country averages of estimated standardised latent factors for major facets of science digitalisation

Scientists in different countries exhibit distinct patterns of digitalisation across these four main facets (Figure 1). For example, the digital “profile” of authors in India is highly tilted toward the use of advanced digital tools, whereas authors in Australia, the United Kingdom and Ireland are geared more toward digital identity practices. Much of this inter-country variation is driven by scientific specialisation, though differences also exist within fields.

The unfulfilled promise of data or code sharing

Using and producing data and code are defining features of scientific research in the 21st century. In 2017, about 65% of all scientific publications resulted in the development of new data or code, according to ISSA, ranging from 80% for computer science publications to 40% for arts and humanities publications (Figure 2). Publishers, funders and policy makers have increasingly emphasised the importance of expanding access to data, yet interpersonal exchanges are by far the most common sharing practice among scientific authors, and only 40% store their data or code in repositories. Furthermore, it is often not possible to reuse data, as shared data and code are rarely accompanied by metadata or rendered compliant with relevant standards. Data and code curation and sharing practices are more common in biochemistry and life sciences than in other fields. Authors also reported that nearly 70% of scientific publications are openly available free of charge one year after publication.

Figure 2. Scientific production resulting in new data or code, by science field

Percentage of authors with outputs in each category


A new paradigm of data-intensive research

ISSA results show that over 40% of authors across all fields use computational and simulation methods in their research work. ISSA also provides evidence on the adoption of advanced digital tools and practices in science – including big data analytics, robotics and the Internet of Things – which facilitate the collection, processing and analysis of large amounts of data. The use and development of big data, for instance, is more prevalent in computer science and biochemistry, while autonomous machines and sensors are more widespread in engineering.

Understanding the digital gaps in science

Scientists surveyed in ISSA say that digital access to scientific outputs is largely driven by social norms and peer expectations, rather than formal sharing requirements of publishers, funders or institutions. This suggests that measures mandating data access should recognise the need to shift social norms around the use of scientific commons and align them with career objectives. Scientists also cite dissemination costs, intellectual property protection, and privacy and ethical issues as major obstacles to digital access.
There are important demographic differences in how scientists use digital tools, as well. Female authors, according to ISSA, are less likely to use advanced tools and data/code sharing practices than their male counterparts. By contrast, they are more likely to engage in activities to build and maintain their digital identity, and to communicate information about their work online. Compared to their younger peers, older authors appear less likely to seize opportunities brought about by digitalisation.

Challenges for scientific authors in the digital era

When asked about the main challenges involved in their digital work, scientists often cite access to data, skills and infrastructure, with authors in developing countries most frequently citing infrastructure as a priority. Aside from domain knowledge, scientists across nearly all fields consider data collection and curation skills as a most important challenge. Advanced programming skills appear to be more crucial in computer science, earth and planetary science, and mathematics, while legal knowledge related to intellectual property, privacy and confidentiality seems to be key for authors in medicine and health. Women and all authors involved in data dissemination practices assign greater importance to data collection and curation skills, and programming skills are more relevant to those involved in advanced digital practices.

Impacts of the digitalisation of science: Perceptions and incentive patterns

Scientists, on average, have a positive opinion of digitalisation, with a majority believing it has the potential to promote collaboration – particularly across borders – and improve the efficiency of science. They appear less optimistic, however, about the impact digitalisation could have on incentives and rewards systems for research. Many are concerned about being evaluated exclusively on their quantifiable digital “footprint”, without due attention to the quality of their output. They are also wary of the private sector’s role in providing digital solutions to assist their work. Younger authors are generally more positive than their older peers, except with respect to the impacts of digitalisation on the incentive system, which may reflect concerns about their future careers.

The study fails, however, to find a correlation between actual digital behaviours and monetary rewards within science systems. There is no evidence of an earnings premium among scientists from using advanced digital tools or engaging in data sharing. Similarly, there appears to be no positive correlation between the use of advanced digital tools and frequently used measures of research influence, including normalised citations or journal prestige. But the study does find that data/code sharing practices are linked to higher measures of scientific influence, supporting the hypothesis that greater openness leads to greater visibility and confers a citation advantage.

While digital practices do not seem to be directly financially rewarded in science, a more intensive use of digital tools is correlated with a greater involvement in activities beyond core research. For instance, scientists who use advanced digital tools more intensively are more likely to be involved in business managerial activity (e.g. start-ups), or to apply to, or register for, intellectual property rights protection. This, in turn, may raise questions about the feasibility of retaining digitally proficient scientists within the science system.

Meeting emerging policy needs: the potential of the ISSA survey

Although digital activity in science is pervasive, its distribution and nature is highly uneven across fields and sectors. It remains influenced by norms, incentives, experience, skills and data availability. Given the rising importance of data for research, both policy makers and scientists can do more to seize the opportunities that the digital transformation presents. There is also a strong case for closely monitoring its governance (OECD, 2020b).
This study highlights the potential of ISSA to better track the issues that matter to the global scientific community and support a collective, international policy discussion. The approach underpinning ISSA allows for the timely collection of granular data on science, in combination with bibliographic information and other data sources. The survey, together with other sources, has the potential to become a valuable resource for investigating how the scientific process takes place and measuring the multidimensional impacts of scientific work. ISSA can also be adapted to meet emerging research and policy needs, representing a major opportunity for policy analysis in other OECD areas of focus, such as the future of research careers and the link between science and society.

**The OECD International Survey of Scientific Authors**

ISSA is an initiative of the OECD Committee for Scientific and Technological Policy (CSTP), carried out under the aegis of its Working Party of National Experts of Science and Technology Indicators (NESTI). The global online survey targets authors of scientific publications and aims to provide evidence on various aspects of science and to inform science policy discussion within and across countries. This is an innovative approach to the way the OECD collects and reports data on science, complementing the statistical evidence that is currently available. As part of the OECD Blue Sky STI measurement agenda (OECD, 2018), ISSA responds to the call from OECD science ministers at their 2015 Daejeon meeting for evidence-based responses to the rapid evolution of digital technologies and its impact on STI.

ISSA was piloted in 2015, with a focus on the link between scientific publishing and open access (Boselli and Galindo-Rueda, 2016). This pilot gathered responses from around 6 000 corresponding authors from seven diverse scientific domains. A new survey conducted in 2018 gathered evidence on the digitalisation of science across all fields, with data collected on nearly 12 000 scientific corresponding authors worldwide. Further methodological information on this study can be found in Bello and Galindo-Rueda (2020b). Anonymised micro-data for ISSA2 and ISSA1 are available at http://oe.cd/issa.

**Further reading**


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