VSB TECHNICAL UNIVERSITY OF OSTRAVA | PhD ACADEMY

A GUIDE TO RESEARCH AND DEVELOPMENT (Not Only) for Doctoral Students

David Řehák
Pavel Šenovský
Nela Stebnická

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Reviewers:

Full Professor Jana Kukutschová, Ph.D.
Vice-Rector for Research and Development, VSB – Technical University of Ostrava

Assoc. Professor Dr. habil. Pavel Foltin, Ph.D.
Vice-Rector for Internal Management and Quality Control, University of Defence

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Foreword

Dear doctoral students and early-career researchers,

scientific and research activity currently forms an integral part of the activities of every university. The results of research, development, and innovations are evaluated every year and form an important basis for funding, but also for evaluating the prestige of these institutions.

It is a matter that interests me as a rector, as well as the rest of the management of universities here and abroad. But why should it interest you as starting doctoral students? I will tell you a secret, this prestige does not arise by our choice, but by careful scientific work and research, carried out by each of us, including you, the students.

As they say, unless research is published, it does not exist. Writing a good article is not easy, though. It must be well-framed in the current state of knowledge, and every thought must be properly justified and cited.

Success requires using several specialised tools, such as various databases of existing research information, including document repositories. Over time, you will need to get involved in research projects or even request them yourself. The system of science is very complex in this regard, perhaps even discouraging to attempt to penetrate it.

However, succumbing to such feelings would be a mistake. Science is beautiful. It will enable you to meet the most interesting people and learn from them directly during your studies or indirectly by studying their ideas published in professional books and articles. Conversely, your thoughts and opinions will influence others one day.

With scientific work, you will contribute to increasing the level of knowledge in your field. We would hardly find a nobler mission. Therefore, I am glad you have chosen to read this edition of *A Guide to Research and Development (Not Only) for Doctoral Students* that summarises the information needed to start your scientific career.

I firmly believe that this book will provide you with answers to a number of your questions that will accompany you during your doctoral studies but will also facilitate the beginnings of your scientific research.

I wish you a pleasant read and much success in the future.

Full Professor Václav Snášel, Ph.D.

Rector of VSB – Technical University of Ostrava

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Introduction

The media, the professional public, and also the general public often deal with issues of the information society and the need to build a knowledge-based economy. However, this change cannot happen without increasing research capacities and without a shift in the quality of the conducted research as such.

Early-career researchers, in particular, often encounter a problem when trying to work in an environment with complex rules of operation. They subconsciously feel they should comply with them, but, at the same time, do not know how. They obtain a lot of information from their friends, colleagues, or supervisors, but the information is often incomplete and obtaining it is time-consuming.

This book is intended just for such people as a certain introduction to the complex science and research environment, allowing them to adapt much faster and more efficiently to the settings. For this purpose, some passages of the book are highlighted with the following meaning:

FOR FURTHER STUDY

A text marked like this contains a link to other study materials the authors of this book recommend studying for better understanding of the discussed issue.

NOTE

A note contains an additional explanation that can be considered interesting, allowing readers see the discussed issue in a broader context.

NOTICE

A notice highlights a particularly important message that definitely should not be skipped.

The book is divided into seven interconnected chapters. In the first chapter, the reader gets acquainted with the basics of the modern concept of science and scientific research. It is followed by the second chapter providing the reader with the tools needed for an effective choice of where to publish and how to measure the impact of the published results. Thus, Chapter 2 is devoted to scientometrics.

Chapter 3 deals with the legal regulation of the status of science, research, and innovations in the Czech Republic. This chapter also describes the role of the state in the field of science and research, as well as the basic philosophy of evaluating individual research organisations and grant programs.

The fourth chapter deals with providing support for research and development – grants, as basic means of financing research activities. This chapter discusses individual support providers and their focus, from EU framework programmes to departmental support providers.

The issue of reporting in the Register of Information on Results (RIV) and the method of evaluating science and research are explained in Chapters 5 and 6. The explanation focuses mainly on individual types of science and research outputs, the method of their reporting, and evaluation.

The final chapter provides practical guidance on publishing results. It points out the possibilities of self-presentation and promotion of achieved results using available and open-access tools.

1 Methodology of scientific work, or Introduction to science

Terms such as science, method, or theory are widely known and used in colloquial language. However, when it is necessary to use them in practice, intuitive understanding is insufficient, and for this reason, the basic concepts are explained in this chapter.

1.1 Theory, method, and methodology

Science is a well-known word used in a common language without much thought. The concept of *science* is therefore understood intuitively, which is usually sufficient. For the purposes of this publication, however, it is necessary to define the term precisely.

Encyclopaedic dictionaries [1] use the following definitions of science:

- a branch of knowledge or study dealing with a body of facts or truths systematically arranged and showing the operation of general laws,
- systematic knowledge of the physical or material world gained through observation and experimentation,
- systematised knowledge in general,
- knowledge of facts or principles gained by systematic study,
- the systematic study of the nature and behaviour of the material and physical universe, based on observation, experiment, and measurement, and the formulation of laws to describe these facts in general terms.

Undoubtedly, one could find a greater variety of definitions of what science is (and is not), but that is not the purpose of this book. The common factor in many of them is the systematic way the objective reality is examined. It is an important point because this systematicity is what allows knowledge to move forward.

Systematicity of science requires a certain standardised way of doing research. The investigation process is when a scientist formulates a theory and then tries to confirm or refute it through a series of observations or measurements. These observations (measurements) are made in the same way to minimise the effect of random measurement variations.

Under such conditions, the result of the work can be incorporated into a sorted system of knowledge that can be safely used further to generate new knowledge. Thus, theories are directly dependent on observation methods and technologies used. If, for example, a more precise instrument is used, the result of the new measurement may differ from the measurements made so far. In this case, the original theory supported by the original data needs to be revised or even rejected based on the new data.

Thus, individual findings are approached critically and impartially. When Sir Isaac Newton (1643–1727) laid the foundations of modern physics in the second half of the 17th century with his ideas about gravity and demonstrated that the laws of physics apply not only on Earth but also in the universe, he did so based on a large number of observations, but also calculations that allowed him to formulate the three laws of motion. However, it later turned out that electromagnetic waves do not behave according to these laws, a contradiction that only Albert Einstein (1879–1955) was able to explain with the special theory of relativity (1905) and the general theory of relativity (1915).

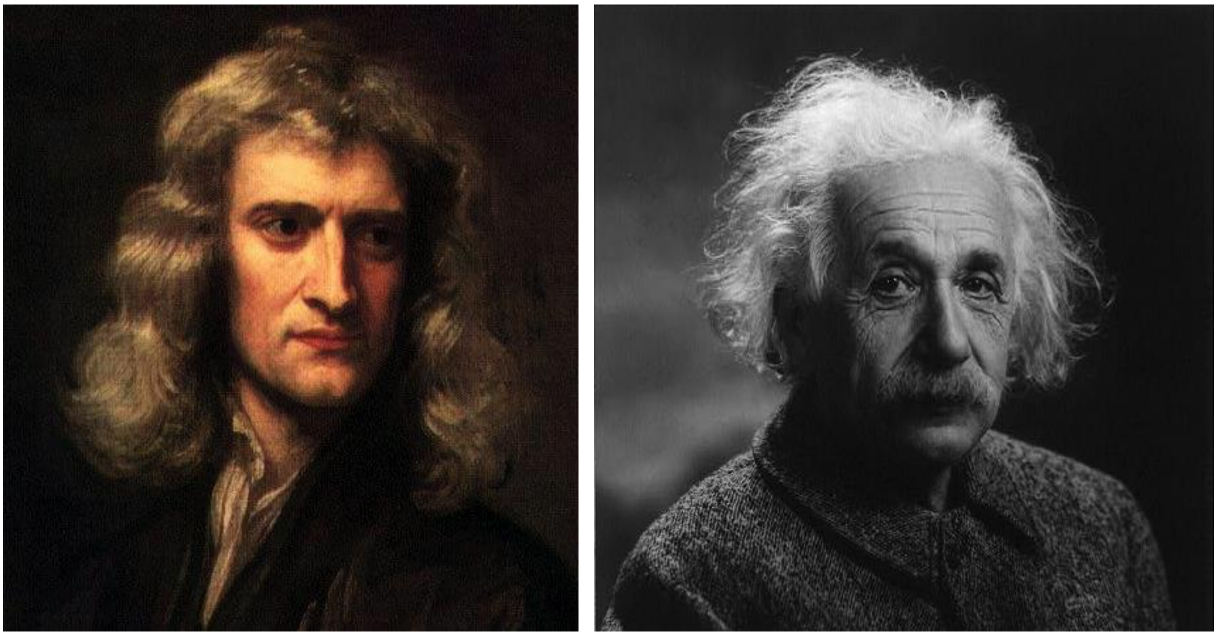

Figure 1: Sir Isaac Newton (Portrait of Isaac Newton by Godfrey Kneller, 1689) and Albert Einstein (Library of Congress, 1947) [2]

Another example can be found in ancient history, specifically the history of ancient Egypt. By careful observation of the nature around them and also of the sky, Egyptian priests were able to predict quite accurately the regular flooding of the Nile River. The flooding then formed the basis for the successful agricultural system of ancient Egypt.

However, in their observations, they encountered several events they could not explain. One of them was what happens to the Sun when it sets. The ancient Egyptians came up with a story in which every evening, the sun god Re sails in his boat into the underground realm of Amnti – the land of the dead – where there is a terrible serpent named Apop that attacks the Sun every evening and every morning. But the sun god Re always manages to defeat it, ensuring the Sun rises again every day.

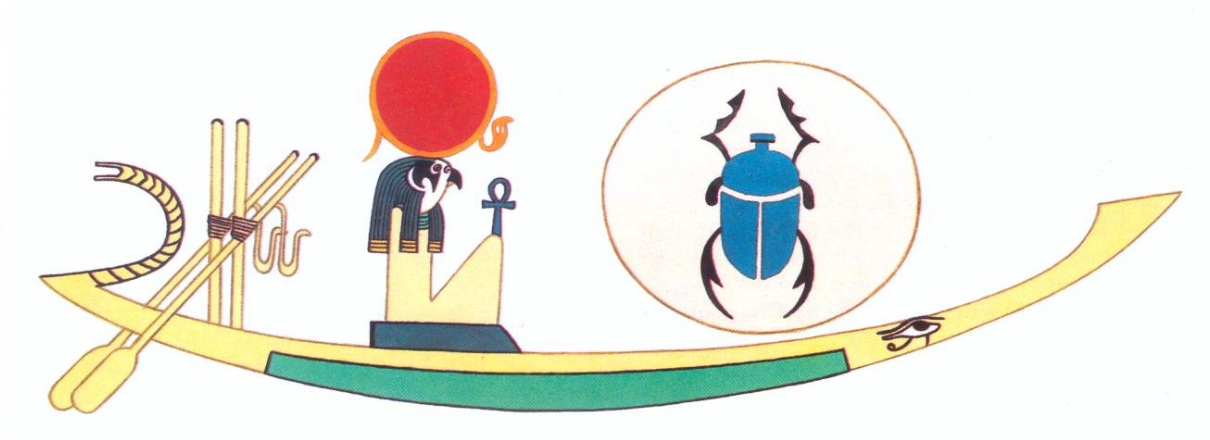

Figure 2: Solar barque of the sun god Re [3]

Why is this beautiful story mentioned in this place? What is its connection to science? There is a significant difference between flood prediction and the struggle of the god Re. Both are based on observation, but while the flood prediction belongs to science, the god Re story is a matter of faith.

Both observations work on logical reasoning and assumptions. The assumptions of science usually include the following:

- there is an objective reality shared by all rational observers,
- the objective reality is governed by the laws of nature,
- the laws can be discovered through systematic observation.

Thus, our ancestors in the distant past correctly identified the necessity of the existence of relations in their environment but did not possess sufficient knowledge to be able to discover the nature of these relations. At the same time, the observed events (e.g., sunrise) were so important that they had to take an authoritative stand on them.

Science and faith were, therefore, very closely interconnected in the past, but the modern concept of science is different. In scientific research, we try to free ourselves from all assumptions that cannot be based on observation or measurement, and have been reached only by intuition ("common sense"). Intuition, nevertheless, has its place in modern science. An intuitive understanding of a problem can help establish an initial working hypothesis, but this must then be subjected to critical examination based on "hard" data and, if necessary, further work.

What about the division of science or the philosophy of approach to scientific research in general? Traditionally, the different attitudes of the great ancient philosophers Aristotle and Plato have been cited in relation to the principles of science. Aristotle (384–322 BC) in his works *On the Soul* (e.g., in the translation of J. A. Smith [4] or the annotated edition of Gendlin [5]) and *Metaphysics* (e.g., in the translation of W. D. Ross [6]) emphasises the necessity of independent investigation within various scientific disciplines. Plato (427–347 BC), by contrast, prefers dialectics as a superior and unifying discipline that takes propositions not as undeniable principles but as hypotheses that need to be tested. He demonstrates this view through a fictional topic-oriented conversation, often between Socrates (469–399 BC) and another person, both holding markedly different points of view (see, e.g., Euthyphro [7]).

Although the meaning of Plato's dialectics has shifted considerably throughout history, the basic principle of critical thinking and proof has been preserved in modern science. However, research within individual disciplines, as preferred by Aristotle, was a work of necessity. It turned out that the amount of information around us that must be accommodated in scientific inquiry to cover the full range of problems in our world is so vast that a single person cannot do so.

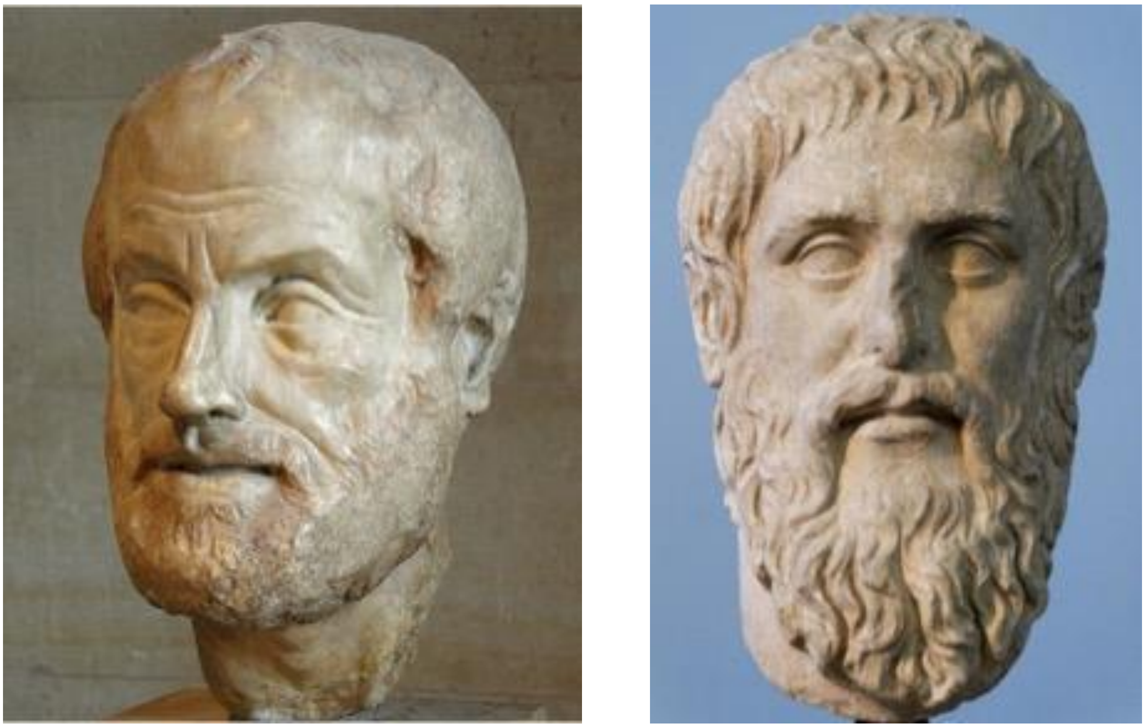

Figure 3: Busts of Aristotle and Plato

This problem was solved logically – by specialisation. Scientists/researchers, therefore, specialise in particular disciplines, which brings advantages – it allows them to go deeper into a chosen problem or its parts. On the other hand, it brings certain negatives as well, usually identified as typical characteristics of individual disciplines.

These characteristics are well described by Kuhn [8]: disciplines create their own systems of methods and nomenclature – in general, patterns that a researcher must adopt to be able to work scientifically (or be successful) in a given field. Kuhn refers to such generally accepted patterns as *paradigms*. He views them in two different ways:

- in a narrow sense, as an overall arrangement of assumptions, values, methods, etc., shared by members of a given community,

- in a broader sense, as specific solutions to problems that, if used as models or examples, can replace existing rules as the basis for solving the remaining problems of "ordinary science[1]".

FOR FURTHER STUDY

The issue of paradigms is very interesting, but unfortunately, there is only limited space to address it in this text. Therefore, we recommend Thomas S. Kuhn's book *The Structure of Scientific Revolution* [8].

Such paradigms allow researchers gain expertise in a given field relatively quickly, but on the other hand, they may create a barrier for researchers working in other fields (who adopt their own paradigms).

Second Kinkler's Law[2] says: *"All the easy problems have been solved"*. Modern researchers are thus left with only the more complex ones that often require interdisciplinary collaboration. Differences in methods and ways of understanding the problem must then be considered when transferring knowledge between disciplines.

Science classification (to which various disciplines belong) is more complex, as it has changed significantly over time. As late as the 19th century, encyclopaedias (e.g., the Encyclopædia Britannica) gave a three-component system of sciences:

- logic (sciences of thinking, sciences of sciences),
- nature (natural sciences),
- soul and mind (humanities).

From today's perspective, the division into natural sciences, social sciences, and humanities is more common. In addition, we often speak of applied sciences that apply scientific knowledge to practical areas (technologies, inventions, innovations).

The Frascati Manual [9], published by the Organisation for Economic Co-operation and Development (OECD), which sets out the basic framework for statistical monitoring of R&D indicators, distinguishes six main fields:

1. Natural Sciences,
2. Engineering and Technology,
3. Medical and Health Sciences,
4. Agricultural and Veterinary Sciences,
5. Social Sciences,
6. Humanities and Arts.

[1] By ordinary science, Kuhn means ordinary research that does not bring new revolutionary knowledge, i.e., does not significantly change the scientific community's view of a problem and how to solve it.

[2] Kinkler's laws fall within the humorous Murphy's laws.

These fields are very often referred to by the acronym FORD (Fields of Research and Development). The FORD breakdown is currently also used in the Czech Republic to evaluate research organisations. It is not the only classification used in practice but the most widely used worldwide.

All science classifications are always purpose-built to some extent. For this reason, individual countries create their own science divisions into different groups. Such divisions can be used for the evaluation of research organisations but also, for example, in the accreditation procedures for individual fields of study at universities.

Another concept very closely related to the concept of *science* is *research*. The Oxford Dictionary [10] defines research as *"the systematic investigation into and study of materials and sources in order to establish facts and reach new conclusions"*.

A more detailed definition is provided by the Frascati Manual [9] which defines *research and development* (R&D) to be consisting of creative activity and systematic work carried out to increase the level of knowledge, including knowledge of humanity, culture, and society, and to devise new ways of applying available knowledge.

According to the Frascati Manual, R&D itself comprises three categories of activities:

- basic research,
- applied research, and
- experimental development.

NOTE

A new edition of the Frascati manual was published in 2015 [9]. The OECD, under whose auspices the document was produced, aimed it as a tool for collecting statistical data on science and research. Over time, this manual has de facto become a standard that, in terms of definitions, has been implemented in legislation (in the Czech Republic, for example, in Act 130/2002 Coll., on the Support of Research and Development from Public Funds and on the Amendment to Some Related Acts [11]) and in the structure of data collected by individual statistical offices.
Moreover, understanding the terminology of the manual is extremely important for understanding the text of grant calls in the Czech Republic and abroad, including calls under the HORIZON Europe framework programme, that use it extensively.

Basic research is defined in the handbook [9] as experimental or theoretical work carried out primarily to obtain new knowledge in the fundamental principles of phenomena or observable facts and which is not primarily aimed at any particular application or use in practice.

Applied research [9] also focuses on original investigations conducted to acquire new knowledge, but it is primarily directed towards a specific practical goal.

In contrast, *experimental development* [9] is systematic work, drawing on research findings and practical experience to produce additional knowledge. It is aimed at creating new products and processes or at improving the quality of existing ones.

Another very important concept is *theory*. *The American Heritage Dictionary of the English Language* [12] says it comes from the Greek *theoria* (observation, reasoning). The very meaning of this word is the following:

- A set of propositions or principles designed to explain a group of facts or phenomena, especially those that have been repeatedly tested or are generally accepted, and can be used to predict the results of natural phenomena.
- A branch of science or art composed of propositions that explain it, accepted principles, and analytical methods as opposed to practice.
- A set of theorems that represent a systematic view of the field of mathematics.
- Abstract reasoning – speculation.
- A belief or principle that guides action or aids understanding or decision.
- An assumption based on limited information or knowledge – conjecture.

The needs of this book are best met by the first definition. According to this definition, in the formation of a theory, assumptions (hypotheses) about the functioning of a particular phenomenon (system, etc.) are formulated and then subjected to repeated testing and verification through appropriate scientific methods. If the hypotheses about the functioning of the phenomenon hold up under such scrutiny, they can be accepted as valid explanations of the phenomenon – theories about its functioning.

The basis for success is the use of *scientific methods*. The Oxford Dictionary [13] defines a scientific method as *"a method or procedure that has characterised natural science since the 17th century, consisting in systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses"*.

In order to be valid and objective, hypothesis testing must be performed using a chosen method repeatedly and ideally by different research teams. For this reason, the scientific method must be defined accurately – otherwise, the obtained results would not be comparable. For this reason, the formal description and publication of the methods used in scientific work are as important as the publication of the results themselves.

The use of methods in practice is also linked to another concept – methodology. The meaning of methodologies is somewhat different from that of methods. While a method focuses on the exact procedure for carrying out the activities described by the method, a methodology works at a level above. It usually does not specify particular activities to be performed, but which methods need to be deployed, when or with what input parameters. A methodology, therefore, describes how one or more methods are deployed to solve a specific problem (to fulfil the purpose of the methodology).

1.2 Model, modelling, verification

When investigating the behaviour of individual objects of interest, scientists are very often limited by practical constraints. Suppose we are investigating the behaviour of a fire in a designed building. It would be very difficult to build such a building, burn it to the ground, and then (once known how the fire will behave) rebuild it with the identified changes.

For this reason, instead of real-world objects, purpose-built, simplified images – models – are often used. For a formal definition of a model, one can use, for example, *The American Heritage Dictionary of the English Language* [12], defining it as:

- a word derived from the Latin *modus* – a standard,
- a small object usually built to scale, that serves as a representation of another, often larger object,
- a schematic description of a system, theory, or phenomenon that contains known or inferable properties (of what is being modelled) and can be used to further study its properties.

It is the third definition that is crucial for the purpose of this chapter. By elaborating and thinking it through, it can be deduced that a model is a purposive view of the system, which considers its important properties (in terms of use). Thus, a model does not contain all the properties of the modelled system but only a subset of them.

The purpose of such a model is then to estimate the behaviour of the real system under conditions corresponding to those modelled. In doing so, we assume that inaccuracies introduced into the model during its design will lead to minor (insignificant) inaccuracies in predicting the behaviour of the modelled system when experimenting with the model.

Thus, in the previous example, the building model of the FSE (fire safety equipment) designer will be different from that of the HVAC (heating, ventilating, air-conditioning) designer or that of the structural engineer, although it still will be a model of the same building.

Thus, the purposefulness of the model allows us to predict the behaviour of the modelled system, but only under certain conditions – such conditions are often referred to as boundary conditions. If any of the observed parameters exceed these conditions, the reliability of the predictions provided by the model decreases significantly.

Considering all the constraints, predictions about the behaviour of the modelled system can be said to make the actual system act as a *ceteris paribus* model. It is a Latin expression meaning "other things equal" or "if all else being equal". When working with a model, it is usually assumed that the other properties of the real system are insignificant in terms of the part of the studied system, so they can be neglected (purposely in terms of the use of the model).

The process by which the essential properties of the studied system are identified, quantified, and used to create a model is called modelling. However, modelling also refers to the process in which a model is experimented with, and its behaviour is investigated. Therefore, to trust the model's predictions, it is first necessary to check that the predictions are consistent with the behaviour of the modelled system, which is done through the *verification* and *validation* process.

The *verification* process is used for computer models when we try to prove that the concept (idea) of the model, its assumptions, and internal operation mechanisms are correctly implemented. However, this approach is also relevant for a variety of other models (computational procedures) that, for example, are solved in the computer.

In many ways, the concept of *model validation* is more familiar. It is a more general term not necessarily associated with models implemented only in a computer, although we validate them as well. By validation, we mean verifying that the model works as it should and is, therefore, from the modeller's point of view, an accurate representation of the system.

Validation can be well demonstrated, for example, on regression models or neural networks. The available data describing the system behaviour of interest are randomly divided into two sets during model building – a larger training set and a smaller validation set, with random selection into both of them. The model itself is constructed based on the training set. Such a resulting model should be able to correctly cover the data used for its creation. However, the model can be considered valid only when it provides correct data even after using a validation set not used in the model creation.

Thus, verification is more of a structural check of the model implementation, while validation is a check of the model's ability to predict the behaviour of the modelled system. For a model to be safely deployed to solve a practical problem, it must successfully pass both the verification and validation processes.

According to the paragraphs above, it would seem that all research areas are covered, at least on a theoretical level, but it is not the case, unfortunately. Back in the 19th century, scientists thought that all the inaccuracies they encountered in their work were due to the poor quality of the models they used, and that problems could be minimised, or even entirely eliminated, if the models were improved. They also believed that all the phenomena they might encounter were solvable by so-called *deterministic models*.

However, practical observations of some phenomena, such as the weather, have shown that this is not the case. Deterministic models of such phenomena can indeed be constructed, but the small deviations by which the model differs from the real system do not remain constant but increase over time.

Formulating models so that their results are sufficiently accurate is very difficult, as Niels Bohr (1885–1962), winner of the Nobel Prize in Physics in 1957, wittily remarked [14]: *"Prediction is difficult, especially the future."* Modelling dynamic phenomena, in particular, is problematic. The main obstacle is the exponential increase in the demand for input data and computational apparatus with increasing demands on the accuracy of the predictions of these models.

This problem was described to some extent in 1814 by the Marquis Pierre Simon de Laplace (1749–1827) [14]; it is often referred to in the literature as Laplace's demon: *"We may regard the present state of the universe as the effect of its past and the cause of its future. An intellect which at any given moment knew all of the forces that animate nature and the mutual positions of the beings that compose it, if this intellect were vast enough to submit the data to analysis, could condense into a single formula the movement of the greatest bodies of the universe and that of the lightest atom; for such an intellect nothing could be uncertain and the future just like the past would be present before its eyes."*

Simply put, the problem with humans, according to Laplace, is that they are not gods. The human intellect is too limited to comprehend the full complexity of the universe, and thus it will never be possible to construct deterministic models of certain phenomena. It does not mean, however, that there is no point in dealing with such phenomena. In fact, experimenting with different model types, scientists have found that although they are unable to model, for example, the weather on a planetary scale and for an indefinite time ahead, they can construct models capable of capturing the processes that occur in a real system.

From today's point of view, the most important person in this field was Edward Norton Lorenz (1917–2008), who laid the foundation for chaos theory in 1963 in his paper Deterministic Nonperiodic Flow [15] by describing the differences in weather simulations. At the time of publication, however, this paper met with complete disinterest.

It has also been proven that even "simple" process simulation can provide valuable information about the system's functioning. However, unlike deterministic models, the results are not directly applicable to the complete prediction of system behaviour. For example, the tendency of a model to converge to a certain state or outcome or the evolution of the simulation process (model trajectory) can be valuable information.

Some idea of the possible results of such a model in graphical form can be gained from Figure 4, for example, as one of the results of a distributed computing project by *climateprediction.net* [16] in 2005. However, this figure should be taken rather as an illustrative view of the result type that can be obtained by dynamical system simulations. In terms of model validity, it should be noted that, given the complexity of climate models, these are the results of highly simplified models that do not cover all the essential properties of climate as it is handled today. However, there is a lesson to be learnt from this criticism as it practically demonstrates the difficulty of interpreting the results of such simulations.

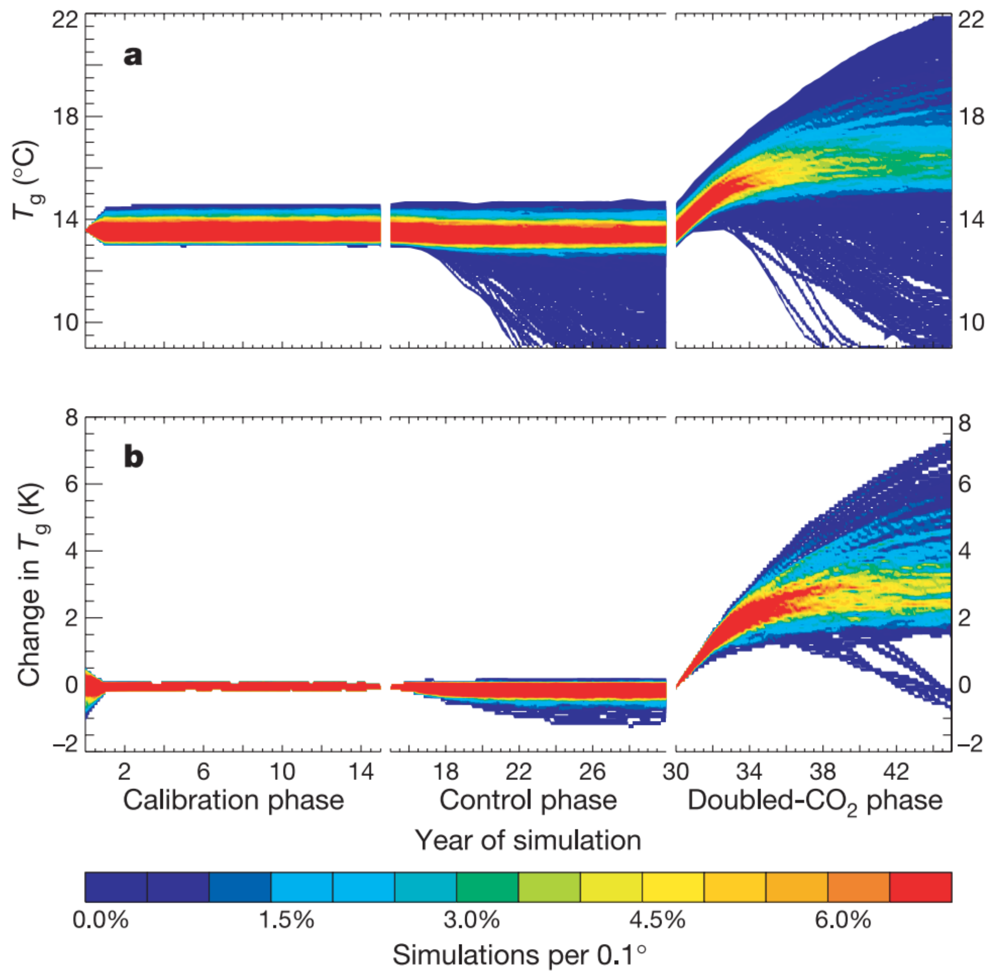

Figure 4: Temperature prediction results from climate models by climateprediction.net [17]

1.3 Citations – their philosophy and purpose (in relation to previous research)

Understanding what science is and how scientific inquiry is conducted (and constrained) allows us to focus on another related area – citing. Scientific discoveries are not usually made by ground-breaking discoveries by individuals – so Tony Stark's[3] example will hardly be followed in the real world.

The contribution of each researcher is relatively small compared to the knowledge achieved by the work of their predecessors. Therefore, a researcher does not (usually) start from scratch with research, but builds on the work of their predecessors. Isaac Newton, for example, was well aware of this fact, writing in one of his letters to Robert Hooke (1676): *"If I have seen further* [than others]*, it is by standing on the shoulders of giants."* From this perspective, citations are meant to formally specify these continuities, allowing the researcher to focus on highlighting their own contributions. But this is not the only reason.

Cynics might argue that the use of citations is mandated in the Czech Republic by the Copyright Act [18], and no further justification is needed. However, such an approach is not entirely

[3] A fictional character from the *Iron Man* comic book series by Marvel.

appropriate, as citing is more than a simple compliance with a legal requirement (not to mention the fact that each state has its own regulations on this issue) – it is one of the few ways, regardless of distance or the time gap, to acknowledge other authors who have made success possible for their followers.

From a formal point of view, there are certain requirements for citations. The most basic one is traceability of the original source. Others relate to how individual publishers of journals and other scientific publications deal with this requirement. From a practical point of view, citations also have another meaning – they can serve as a measure of the importance of an author, journal, or institution. There is even a whole discipline that deals with this issue – we call it *scientometrics.*

Therefore, citation ethics is one of the fundamental moments of a researcher's work – a mistake in citation ethics can lead to the rejection of a manuscript by the journal management. *Plagiarism*[4], the fundamental transgression, can even lead to the premature termination of the plagiarist's work as a researcher.

In the Czech Republic, especially in technical fields, the ISO 690 referencing standard is popular [19]. However, most reputable foreign journals do not use ISO 690, they often define their own sets of rules of how citations should be formatted. The whole situation is even so complex that there are entire software packages whose sole purpose is to get the citations/references right. Probably the largest repository of citation styles, within the Zotero project, contains more than 2,000 of them [20].

Using one of these products can significantly facilitate the work while referencing. For example, the Zotero system was successfully used in the writing of this book. The uncrowned king of such software packages is EndNote [21] by Clarivate. This tool is provided commercially (at a relatively reasonable price for students) but does not support citation styles defined using CSL (Citation Style Language). However, major journals around the world often directly support EndNote and recommend it to their authors.

NOTE

To simplify the work, the ISO 690 citation style has been modified for software tools supporting Citation Style Language (CSL) 1.0.1[5]. This standard is supported, for example, by the open-source tool Zotero [23], the freeware Mendeley [24] or the commercially available Papers [25] and many others.

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[4] Plagiarism is a fraudulent representation of an artistic or scientific work that someone other than the real author wrongfully passes off as their own.

[5] Documentation of the CSL standard is available at citationstyles.org [22].

2 Scientometrics and bibliographic databases

Scientists encounter several problems. Their work is usually based on the work of experts who have dealt with the issue before them. However, they have to access these results somehow. Traditional places where scientists/researchers could access these sources were research/university libraries. The advent of the Internet, massive online expansion of prestigious scholarly publishers, as well as creation of document repositories by universities themselves have changed this practice. The basis for scientific work today is, therefore, usually provided by *bibliographic databases*.

The problem can also be approached in reverse, in the sense of when research is completed – where to publish the result so that its impact on the scientific community is as great as possible. A related question can also be asked – how to measure the impact of published research results, or the authors and research institutions that produce them? Such an issue is dealt with by *scientometrics*.

2.1 Introduction to scientometrics

The English word *scientometrics* comes from the Latin words *scientia* (knowledge) and *metrein* (to measure). It is a scientific field that studies the development of science using quantitative indicators of scientific information. These indicators are, for example, the number of publications in journals of a certain type, the number of citations of individual articles or authors, etc. It deals with the measurement of quality and quantity in science.

The founder of scientometrics is the American Dr Eugene Garfield (1925–2017) who, in the 1950s, when creating expert systems based on indexed scientific information and citations, noticed that such indexed data could be used to track the evolution of science itself. This way, he laid the foundations of one of the most extensive scientometric and citation databases of our time – *Web of Science*. Today, there are several giant databases serving as a source of scientometric data, such as Web of Science, Scopus, PubMed[6], and many others.

The most important scientometric indicators for the evaluation of science and research in the Czech Republic are the Impact Factor (used by the Web of Science database) and the SCImago Journal Rank (used by the Scopus database). There are also a number of indices that can provide information about the performance of individual authors or groups of authors, e.g., within a single research organisation (RO). Examples of such indicators include the h-index or its standardised version, the h-i index, the g-index and many others.

[6] PubMed is a citation database containing more than 22 million citations from articles and books published in biomedical fields.

2.1.1 Journal sciometrics

Impact Factor (IF)

Eugene Garfield himself sees [26] the origins of the Impact Factor in 1955 in connection with the publication of an experimental index of citations in genetics. These efforts were followed in 1961 by the first Science Citation Index, which no longer focused on a single discipline. In order to provide such scientometric information, Garfield founded the Institute for Scientific Information (ISI) in Philadelphia (USA) in 1960. Then the publication of Journal Citation Reports (JCR) followed, now available through an interface integrated into Clarivate Analytics' Web of Science. [27]

Journal Citation Reports provide quantitative tools for ranking, evaluating, categorising, and comparing journals, with the Impact Factor being the key tool, representing the average number of citations of an average publication in a given scientific or professional journal. The Impact Factor is a useful tool in clarifying the meaning of absolute (total) citation frequency. It eliminates some of the one-sided factors that favour, for example, large journals over small journals, or journals with more issues over less frequent journals, or more established journals over new journals. The Impact Factor is evaluated annually by the US Institute for Scientific Information (ISI) for a large set of selected scientific journals and published in Journal Citation Reports.

The Impact Factor expresses the impact of individual journals according to how they were cited in the two previous years (e.g., the Impact Factor in 2013 is based on data from 2011–2012). It has three decimal places and is calculated according to the following equation (1) [28]:

$$IF_1 = \frac{A}{B} \tag{1}$$

where A = the number of citations in 2013 of articles published in 2011–2012 (this is a subset of the final number of citations in 2013, including older citations as well); B = the total number of articles published in 2011–2012; and IF_1 = the journal's Impact Factor for 2013.

In addition to the traditional Impact Factor, the 5-year Journal Impact Factor (5-IF) is also used – it expresses the impact of journals in terms of how they were cited on average in the five previous years. It also has three decimal places, and the equation (2) for its calculation is as follows [28]:

$$IF_5 = \frac{C}{D} \tag{2}$$

where C = a number of citations in 2013 of articles published in 2008–2012; D = the total number of articles published in 2008–2012; IF_5 = the journal's 5-year Impact Factor for 2013.

In practical terms, the 5-IF is usually higher than the normal IF. The reason is clear – over a longer period of time, more citations accumulate for individual articles. Different disciplines have different citation practices, and the preference for IF or 5-IF corresponds to this. In IT, for example, there is a very rapid exchange of ideas, published mostly at conferences, which goes hand in hand with a rapid accumulation of citations and a preference for a normal IF. In contrast, in the humanities, citation ramp-up is usually very slow, often even longer than the observed 5-year interval, and therefore 5-IF is often preferred.

Journal Citation Indicator (JCI)

The impact factor is a traditional indicator, but, in a way, outdated, without the ability to deal with attempts at manipulation. For this reason, in 2021, JCR introduced a new indicator – the Journal Citation Indicator (JCI). This indicator calculates the impact of citations by comparing them to a cohort of similar articles and is expressed as a ratio or percentile. The cohort is determined by discipline, publication type and year of publication. Thus, the JCI value is calculated [29] as the average Category Normalized Citation Impact (CNCI) for all articles and reviews published in the last 3 years. CNCI [30] is a metric describing the relative citation impact of an article as a ratio of citations to the global base (see Equation 3):

$$CNCI = \frac{c}{e_{ftd}} \tag{3}$$

where c = number of citations; and e_{ftd} = expected number of citations given the time, field, and publication type. CNCI = 1 represents average impact, CNCI > 1 represents above-average impact, and CNCI < 1 represents below-average impact.

SCImago Journal Rank (SJR)

SCImago Journal Rank is an indicator developed by the SCImago Research Group, led by Professor Felix de Moya of the Universidad de Granada in Madrid, to assess the importance of journals based on data contained in Elsevier's Scopus database.

A relatively complex algorithm based on Markov chains is used to calculate the SJR (see Equation 4) [31]. Thus, the algorithm treats the importance problem as a network where individual nodes represent publications, and individual citations define the connections between nodes (publications) in the network.

The algorithm starts the computation at a preset level and iteratively recalculates the PR values of individual nodes until there is a solution that changes only insignificantly between iterations (stable solution). The prestige of individual nodes (publications) is redistributed in each iteration according to how each publication is cited:

$$PR(Node_i, it_k) = \frac{1-\lambda}{N} + \lambda \sum_{j=1}^{N} (Connection_{(i,j)}) \cdot PR(Node_j, it_{k-1}) \tag{4}$$

where the importance (prestige *PR*) of node *i* in algorithm iteration *k* is set as the sum of the relative prestige carried by all nodes connected to node *i*. The amount of prestige carried from node *j* to node *i* corresponds to the strength of the connection between them. This strength is calculated as the fraction of references in node *j* in the considered year that led to node *i*. The random jump factor (the first term of Equation 4) is included to ensure the algorithm convergence. [31]

The aim of this indicator is to provide a relevant comparison of scientific journals in different fields with different citation approaches (it is generally known that each scientific field has a different research methodology, hence also different numbers of cited materials).

The list of journals with the SJR indicator is available not only in the Scopus database but also freely on the SCImago Journal and Country Rank webpage [32] (see Figure 5). Within this portal, there is also a ranking of scientific activity for individual nation states and the possibility to compare individual journals and countries.

The difference between the values of the currently most important indicators of the Web of Science and Scopus databases for 2020 is presented in selected prestigious scientific journals Nature, Science and Cell (see Table 1).

Source Normalized Impact per Paper (SNIP)

The SNIP citation indicator was introduced in 2010 by Henk F. Moed [33] from the University of Leiden, the Netherlands, as a simple tool for assessing the impact of journals. The calculation method is shown in Equation (5). However, shortly after its publication, this indicator was subjected to quite a lot of criticism, which led to its change [34]. SNIP is, therefore, currently (since 2012) used in a slightly different form (see Equations 6 and 7):

$$SNIP_{orig} = \frac{RIP}{RDCP} \tag{5}$$

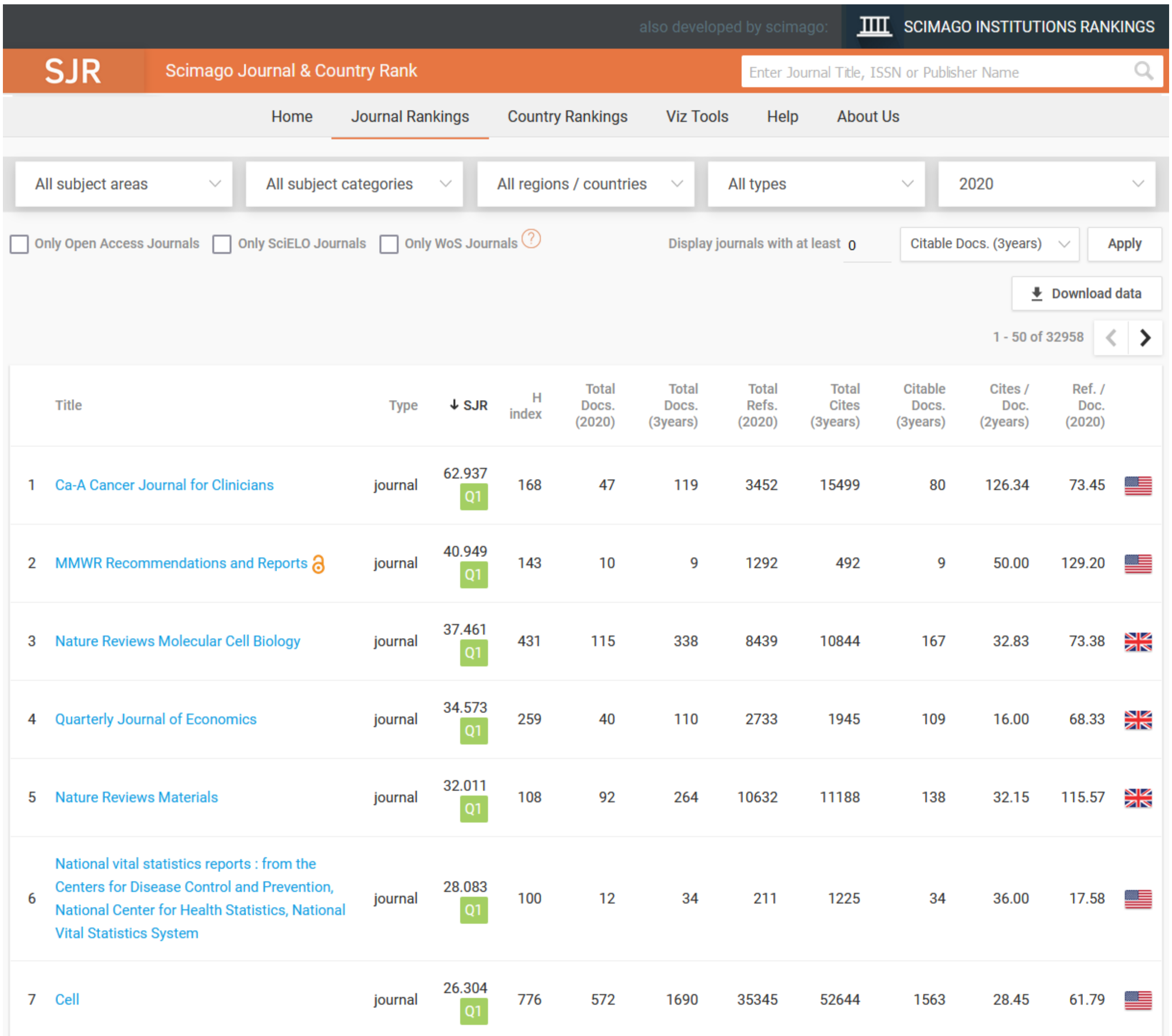
$$SNIP = \frac{RIP}{DCP} \tag{6}$$

$$DCP = \frac{1}{3} \cdot \frac{n}{\frac{1}{p_1 r_1} + \frac{1}{p_2 r_2} + \ldots + \frac{1}{p_n r_n}} \tag{7}$$

where *SNIP* = source normalized impact per article (*orig* means original, nowadays no longer used version of the formula); *RIP* = raw impact per paper – direct number of citations per article of the journal; *RDCP* = relative database citation potential of a specific field; *DCP* = database citation potential – citation potential of the journal in the database; *n* = the number of publications in the journal field; and r_i = the number of references in the *i*th publication to publications that appeared in the three previous years in journals registered in the database.

The calculation of p_i is more complicated. First, we select the *i*th publication in the journal field, then take all publications in the same journal and the same year as the selected publication, and finally calculate p_i as the proportion of those publications that have at least one active reference.

The SNIP indicator is calculated in the Scopus database. Similarly to SJR, it is possible to see a list of journals with the value of this indicator in the Scopus database as well as free of charge on the CWTS Journal Indicators webpage [35].



	Title	Type	SJR	H index	Total Docs. (2020)	Total Docs. (3years)	Total Refs. (2020)	Total Cites (3years)	Citable Docs. (3years)	Cites / Doc. (2years)	Ref. / Doc. (2020)
1	Ca-A Cancer Journal for Clinicians	journal	62.937 Q1	168	47	119	3452	15499	80	126.34	73.45
2	MMWR Recommendations and Reports	journal	40.949 Q1	143	10	9	1292	492	9	50.00	129.20
3	Nature Reviews Molecular Cell Biology	journal	37.461 Q1	431	115	338	8439	10844	167	32.83	73.38
4	Quarterly Journal of Economics	journal	34.573 Q1	259	40	110	2733	1945	109	16.00	68.33
5	Nature Reviews Materials	journal	32.011 Q1	108	92	264	10632	11188	138	32.15	115.57
6	National vital statistics reports : from the Centers for Disease Control and Prevention, National Center for Health Statistics, National Vital Statistics System	journal	28.083 Q1	100	12	34	211	1225	34	36.00	17.58
7	Cell	journal	26.304 Q1	776	572	1690	35345	52644	1563	28.45	61.79

Figure 5: List of journals with SCImago Journal Rank indicator [36]

Table 1: Difference between Web of Science and Scopus indicator values

Journal	Impact Factor (IF)	Journal Citation Indicator (JCI)	SCImago Journal Rank (SJR)
Nature	49.962	8.70	15.993
Science	47.728	7.63	12.556
Cell	41.584	7.09	26.304

Journal ranking

Although the above-mentioned indicators of journal "relevance" appear to be universal – directly comparable – we find that it is not the case when examined closely. It has already been pointed out that research is conducted in different ways in different disciplines, which leads to the fact that each discipline develops its own publishing and citation practices. Thus, comparing indicators such as IF between disciplines is not very meaningful.

This problem can be dealt with to some extent through partial comparisons made within the field. The usual approach is to assign a journal to one or more fields/subfields (e.g., FORD, depending on the field breakdown used by the data source), and within these subfields, journals are ranked in descending order of their IF. The ranking obtained within a subfield is comparable. The comparison assumes that the publication/citation patterns are the same within a subfield.

This assumption is never 100% valid, as modern science is extremely complex. Therefore, inclusion in the FORD subfield may not be granular enough to accurately determine a journal's position or importance in the field. More interesting from this perspective is dividing the entire subfield into so-called quartiles, usually abbreviated Q1–Q4. They divide the entire subfield into four groups of 25% each. Q1 then contains the most prestigious journals, while Q4 includes those with the lowest IF. For finer ranking purposes, it is also possible to use deciles (10% each) or percentiles (1% each).

Scientists' ambition is usually to publish the outputs of their research in the most prestigious journals possible to maximise the potential impact of the article on the scientific community. Therefore, a frequent recommendation is to publish articles in journals with an IF ranking them in Q1 or Q2, where the highest impact in the field can be expected.

Criticism of IF and similar indicators

Although IF can provide good information, e.g., when selecting a journal suitable for publication, it is not a problem-free indicator. Since IF, or journal quartile, is used to assess the quality of publication performance of individual researchers (e.g., for career advancement), but also of entire ROs, there is a natural pressure on journals to try to achieve the highest possible ranking. It leads some journals to set their own publication rules (e.g., requiring citations from a given journal to be present in newly published articles) to maximise their ranking position.

In the past, there have been cases where several journals agreed to cross-cite each other's articles to increase their Impact Factor quickly and dramatically. Such behaviour can be considered unethical and has practical implications similar to doping in sports or cartel agreements in the trading market. Therefore, the way performance is measured in this respect distorts the very nature and purpose of the performance measurement system as time goes on.

If such practices were left unchecked, the indicator value would quickly be degraded, and the rating system would be skewed towards journals that practise such methods. It would subsequently lead to pressure on journals that have not used similar practices to introduce them or to retreat in terms of market importance.

Some indicators, such as SJR, are more resistant to similar manipulations. IF, however, does not contain any "automatic" defence mechanisms to minimise the consequences of such manipulation. Thus, in the case of IF, potential corrections at the level of the bibliographic database (i.e., WoS) must be made, e.g., by stopping the journal from being indexed, and thus making it drop from the rankings altogether.

2.1.2 Measuring individual performance

Hirsch index (h-index)

The *h*-index was created in 2005 by the American professor Jorge E. Hirsch (1953–) from the University of California [37]. The index evaluates the publication activity of individual authors, groups of authors (e.g., within an institution), or entire institutions.

An author's *h*-index can be calculated relatively simply by ranking the author's publications in descending order by citations (excluding self-citations). The *h*-index will be equal to the publication rank whose citation number is equal to or greater than the rank. In other words, the *h*-index is the number *h* that indicates the number of publications that have been cited at least *h* times (see Figure 6). For example, an *h*-index of 6 means that the author has six papers that have been cited at least six times each.

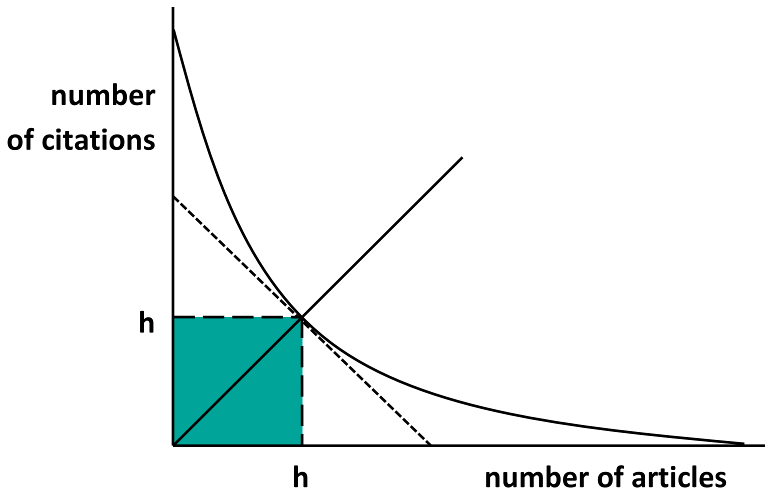


Figure 6: H-*index determination scheme [37]*

The determination of the *h*-index for groups of authors and institutions is similar, except that the basis for the calculation is the list of all authors belonging to a given group or institution.

Although the calculation and interpretation of the index are relatively straightforward, some important citation aspects need to be taken into consideration. Since different disciplines differ in citation rate and frequency, the *h*-index can only be used correctly to compare scientific performance within a single discipline. Another specificity is the time period of the author's activity.

Writing publications and getting them cited takes time. In terms of the *h*-index, authors who have been working in science for a long time are favoured over those who have been there only for a short time. Thus, it makes no sense to compare the h-indexes of a PhD student and a professor, even if they work in the same field. What is relevant in this case is not the difference in their academic titles but the length of their scientific work.

The *h*-index value can be found in the following ways:

- via the Web of Science database that calculates the *h*-index for any set of records for a specific query (author, institution, subject area, etc.). Click the "Create Citation Report" icon on the list of searched records and let the citation analysis be generated. The *h*-index will be displayed among the basic citation data.
- via the author's profile in Publons [38] (if created) that also uses data from Web of Science.
- via the Scopus database that provides the *h*-index value in a similar way to Web of Science, i.e., for a selected group of retrieved records. The *h*-index is determined using the "View Citation Overview" tool and also within individual authors' profiles[7] (by Author ID).
- via the Publish or Perish software [39] based on data from Google Scholar (for more details, see Chapter 7). Alternatively, the *h*-index reads directly from the scientist's Google Scholar profile [40].
- If the author has a profile on ResearchGate [41], the *h*-index is calculated from all publications indexed by the network.
- "Manually" based on a list of publications sorted in descending order by citation count.

When calculating the *h*-index, the purpose of the calculation must also be taken into account. Certain "qualitative" restrictions may be applied – e.g., the basis for the calculation may be limited to Web of Science (or Scopus).

[7] When using the scientist profile in citation databases, it is necessary to be aware of certain limitations in the database's ability to identify the scientist. A single scientist may have several profiles in the databases due to incorrect indexation. The *h*-index stated in one of the profiles may therefore provide misleading information, as there may be other cited publications written by the author that were not used in the calculation of the *h*-index.

NOTE

For a practical application of the h-index, Hirsch [37] suggested that in physics, values of *h = 12* and *h = 18* could be indicators for awarding the titles of associate professor and professor, respectively, at major research universities. The Hirsch index would also indicate an author's suitability for membership in selected institutions; specifically, *h = 15–20* and *h = 45 or higher* could indicate memberships in the American Physical Society and the National Academy of Sciences, respectively.

The biggest criticism of the h-index is that it does not take into account the "weight" of the publication, i.e., how many times the article has been cited. For this purpose, in 2006, Leo Egghe [42] created a competing *g*-index that equals the ordinal number *g* of the publication (publications must be ranked in descending order by citation count) for which the sum of all citations is equal to or greater than g^2. An example of comparing the *h*-index and the *g*-index is presented in Table 2.

In addition to the *g*-index, there are several other variants of the *h*-index that attempt to address various weaknesses of this indicator. However, despite all efforts, the *h*-index has not yet been replaced in popularity by any of these variants. As a good basis for studying the *h*-index and its variants, one can recommend the research by Alonso et al. [43] as well as the associated web signpost [44].

Table 2: Example of comparing the h- *and* g- *indexes*

Citation count	Article rank	Sum of all citations	g^2
30	1	30	1
12	2	42	4
9	3	51	9
9	4	60	16
7	5	67	25
6	**6 = h**	73	36
4	7	77	49
4	8	81	64
3	**9 = g**	**84**	**81**
2	10	86	100

Next, let us mention the *h-i* index. It is a normalised form of the *h*-index that responds to publication practices in fields such as experimental physics. It is typical for such disciplines that all researchers who have contributed in some way to the experiment are listed on all papers on the experiment written by the research team. The ATLAS Collaboration research group's paper [45] with 5154 authors can be considered a record in this respect. For the record, the article describes the experimental existence confirmation of the so-called Higgs boson. It is obvious that the relative contribution of individual authors is very small. This article, for example, is 33 pages long, but 9 pages are just a list of authors. Since large teams tend to publish a large number of results, the conventional *h*-index has little predictive power to describe the scientific performance of an individual working in such a team. The *h-i* index, in contrast, normalises the *h*-index per individual researcher (see Equation 8):

$$HI = \frac{h-index^2}{n} \quad (8)$$

where *HI* = *h-i* index and *n* = total number of authors who contributed to the articles counted in the h-index (sum of all authors of all counted articles, including potential repeats).

An overview of other important indicators defined by the Web of Science and Scopus citation databases is as follows:

- *The Immediacy Index* indicates the average number of times an article is cited in the year it is published. This figure indicates the ability of a journal to publish responses to published articles promptly.
- *The Eigenfactor* [46] indicates the degree of importance of a journal to the scientific community. The importance of a journal is estimated based on citations from other important journals. This indicator is compiled and made freely available by eigenFACTOR.org [47]. It has served as the basis for designing other indicators, such as the SJR.
- *The Article Influence Score* (AI) is also developed and made freely available at eigenFACTOR.org [47]. It measures the average influence of a journal article and is calculated every five years after its publication. If the AI for a journal has, e.g., a value of 20, the average article in that journal is 20 times more influential than the average article in the entire data collection. Essentially, the indicator is comparable to the Impact Factor.
- *The C-index* [48] is used to measure the number of citations, but also their quality in terms of citation distance. Citation distance is determined by co-authors, i.e., the citation distance of an author cited by their co-author is 0. If the citation is made by a co-author of a co-author, the citation distance is 1, etc.
- *The Average Percentile* indicates the overall response of a group of publications (citation counts are normalised per year and discipline). It shows how the article performs compared to other articles in the field.
- *The Disciplinarity Index* [49] is the value of the concentration of a set of articles in a particular group of categories (disciplines). It ranges between 0 and 1 (the higher the index value, the higher the concentration of articles in a particular category). It is based on the so-called Herfindahl-Hirschman index, used in economics.

- *Cited half-life* [50] is the median age of citations of journal articles in a given year. For example, a value of 7 for a journal in 2012 indicates that articles published in the journal between 2006 and 2012 are responsible for 50% of the citations to articles in that journal in 2012.
- *Citing half-life* [51] expresses the median age of articles cited in a given journal in a given year. For example, if a journal has a citing half-life of 9 in 2008, it means that half of the cited articles were published between 2000 and 2008 (included).

2.1.3 Indicators and quantitative evaluation of science and research

Since the indicators mentioned above always describe only a part of the performance of a journal, author, or research organisation, obtaining an objective picture of scientific performance is very difficult, if not almost impossible. That is, if such an evaluation is to be based purely quantitatively on these indicators.

Therefore, the long-standing practice of evaluation based purely on such indicators soon became the subject of quite strong criticism. The first comprehensive (and widely accepted) criticism was the San Francisco Declaration on Research Assessment, known as DORA. The Declaration aimed to end the obsession with the Impact Factor as a fundamental indicator of research evaluation.

The exact formulation of the problems of indicator-based quantitative evaluation led to the formulation of the so-called *Leiden Manifesto* that describes ten basic rules that any indicator-based science and research evaluation should meet [52]:

1) Quantitative evaluation should support qualitative, expert assessment.
2) Measure performance against the research missions of the institution, group, or researcher.
3) Protect excellence in locally relevant research.
4) Keep data collection and analytical processes open, transparent, and simple.
5) Allow those evaluated to verify data and analysis.
6) Account for variation by field in publication and citation practices.
7) Base assessment of individual researchers on a qualitative judgement of their portfolio.
8) Avoid misplaced concreteness and false precision.
9) Recognize the systemic effects of assessment and indicators.
10) Scrutinise indicators regularly and update them.

To some extent, the Leiden Manifesto and similar initiatives have brought about a change in perspective on evaluation, at least in terms of how the official R&D evaluation carried out by research organisations in developed countries is carried out (see Chapter 5).

Despite all the above, IF and similar indicators now remain a firm basis for practically all evaluation systems in use.

2.2 Bibliographic and citation databases

Bibliographic databases are generally databases of bibliographic records. They are organised digital collections of references about published materials, such as journal and newspaper articles, conference proceedings, various reports, legislation, patents, books, etc. Unlike library cataloguing records, where information is available mainly on complete monographs, most bibliographic database records provide information preferably on publications of an analytical nature (i.e., articles, papers in proceedings, etc.).

Bibliographic databases provide detailed information about the existence of publications. The records consist of bibliographic citations (author, article title, journal name, year, issue, pages) and content data (keywords, descriptors, optionally abstract). Bibliographic databases may also be specific to a particular academic discipline (e.g., the bibliographic database of the Institute of History of the Czech Academy of Sciences [53]). Many bibliographic databases are protected by proprietary rights, i.e., they are available under the licensed permission of the database centre or centres that index the resources.

While most bibliographic databases contain only publication records, some databases are becoming digital libraries (repositories) providing the full texts of indexed resources (e.g., Emerald [54] or ScienceDirect [55]). Such databases are called *full-text databases*. Other databases combine with non-bibliographic Higher Education institution databases (containing, e.g., bachelor's or diploma theses/dissertations) to form a more complete scientific search tool (e.g., Chemical Abstract Service [56] or Entrez [57]).

A specific group are *citation databases*, or citation indexes, that contain bibliographic data including abstracts and citations of works from all over the world in the field of research and development. This type of databases tracks citation responses to published peer-reviewed texts. In the Czech Republic, the two most important citation databases are used to evaluate the results of research, development, and innovation (R&D&I, VaVaI in Czech), specifically to evaluate articles published in journals and papers in conference proceedings (Web of Science and Scopus).

Important sources for scientific work are the so-called *document repositories*. They are operated within the library services of individual universities or research organisations. Their purpose is to archive and make available documents of various types (research reports, articles, qualifying papers, etc.) produced by the institution, at least those where the current copyright legislation allows it. A typical example of such a repository is DSpace [58], used by several universities in the Czech Republic, e.g., VŠB-TUO [59].

2.2.1 Web of Science

Web of Science [60] (formerly ISI Web of Knowledge) is used to access bibliographic databases managed by Clarivate, primarily the Web of Science (WoS) and Journal Citation Reports (JCR), but also other databases containing abstracts, citations, and possibly full texts of scientific papers covering life sciences, physical sciences, social and socio-economic sciences, and technology.

Web of Science is considered the world's most important information resource in research and development. It contains [61] regularly updated bibliographic data (including abstracts) on articles from more than 34,000 world's leading scientific and technical journals, with a retrospective since 1800. The database also includes the Conference Proceedings Citation Index [62], containing more than 148,000 conference proceedings from all fields of science since 1990.

One of the latest indexes within the database is the *ESCI (Emerging Sources Citation Index)*. The idea behind the launch of the index is very interesting. The index focuses on new (or older) journals that cover new progressive fields (hence the name *emerging*). It could compensate for one of the biggest weaknesses in coverage of traditional indexes, strongly favouring traditional journals publishing in existing, well-defined fields. In contrast to journals with an Impact Factor, journals in ESCI are not assigned an Impact Factor. However, other features of WoS, such as citation tracking, remain.

Journal Citation Reports is a basic information source that offers an overview and bibliometric analysis of selected journals. The citation data in the JCR database is based on the data in the Web of Science database.

2.2.2 Scopus

Scopus [63] is a multidisciplinary bibliographic, citation and reference database from the Dutch company Elsevier that provides information on scientific literature and quality web resources. The database records data from more than 43,000 journals [64]. Thanks to close links with the editorial systems of major publishers, some journals are available in full-text form, often before they are officially published (the so-called articles in press).

Citations are available for indexed articles with a publication date of and after 1969. For older records, this information is not available. The oldest indexed article dates back to 1788. In addition to articles, Scopus also indexes some book series. There are currently 1167 book series, representing more than 292,000 books. Scopus also contains an extensive patent database (49.2 million patents) and a conference papers database (11.7 million papers).

The database includes the *Scopus Journal Analyzer*, which allows one to find out information about selected journals, compare them, and plot the results. Comparison of journals is possible using various indicators, e.g., search by subject area, time range, or SNIP factor.

2.2.3 Databases providing access to full-text sources

Databases can be divided according to their intended use into two basic groups. The first one consists of sources that provide their users with access to *full texts*, usually on a subscription basis, and are intended primarily for direct "consumption" by researchers who use them as a basis for their work, writing articles, etc. The most prominent ones are presented below.

ACS Publications [65] is a full-text database of chemical journals published by the American Chemical Society (ACS) since 1879. The database contains more than 50 journals [66], as well as book series and conference proceedings of this publisher.

Central European Journal of Social Sciences and Humanities (CEJSH) [67] was established as a joint project of the Academies of Sciences of the Visegrad Four in 2004 in accordance with the joint declaration of the Presidents of the Czech Academy of Sciences, the Polish Academy of Sciences, the Slovak Academy of Sciences, and the Secretary General of the Hungarian Academy of Sciences.

The main goal of this project was to create an electronic, freely accessible database, collecting abstracts in English and reviews of scientific journals in the social sciences and humanities from the Czech Republic, Hungary, Poland, Slovakia, Bosnia, Herzegovina, Estonia, Latvia, Lithuania, Serbia, Slovenia, and Ukraine. The purpose was to increase the visibility of R&D outputs. At present, the database indexes more than 1000 periodicals, but with different time coverage and different forms of access – from article abstracts to access to the full text of articles in open access mode (see Subchapter 7.4 for more details).

EBSCO Academic Search Complete [68] contains more than 13,700 indexed journals, of which more than 9,000 are available in full text. In addition, there are many monographs, research reports, or speeches. Academic Search covers the period from 1887 to the present but with varying quality of source indexing. For example, only 1,400 journals are indexed down to the level of individual citations contained in individual articles.

Emerald [69] is a full-text database of the prestigious Emerald publishing house. The database focuses mainly on areas such as technology and management, but also on sociology, law, and education. It currently contains around 230 titles. Approximately 21 million full texts are downloaded annually. The database contains various collections, such as Emerald Engineering Database, Accounting and Finance, Human Resource Management, Information and Knowledge Management, Managing Quality, Marketing, Operations and Logistics Management, and Performance Management and Measurement.

IEEE Xplore [70] is a database providing access to more than 5 million articles aiming mostly at computer scientists, electronics engineers, and professionals in related fields. Most of the indexed articles have been published directly by the Institute of Electrical and Electronics Engineers (IEEE). In addition to articles, it also provides technical standards, making it significantly different from other resources in this category, usually focused only on articles and/or books.

Journal Storage (JSTOR) [71] was founded in 1994 by the University of Michigan but currently operates as a non-profit organisation. Its primary purpose was to provide libraries and their users with a repository of documents from scholarly journals that would be available in full-text (PDF) format. JSTOR currently contains more than 2,800 journals in 75 disciplines.

ProQuest Central [72] is a multi-disciplinary database providing access to most of ProQuest's output and 47 ProQuest databases. It covers 160 subject areas, including business, science and technology, medicine and health, social sciences, and arts and humanities. In addition to these areas, it contains more than 2,300 international newspapers, 340,000 dissertations, etc.

ScienceDirect [73] is one of the largest databases providing access to electronic versions of journals. It contains online journals from Elsevier Science, focused mainly on natural sciences, technology, computing, mathematics, economics, management, etc. The scientific journals form the largest part of the document repository (more than 2,650 titles containing more than 19 million articles), but there are also more than 43,000 books, textbooks, and manuals.

SpringerLink [74] is a full-text database with scholarly journals and books, mainly from Springer Verlag, in technology, medicine and natural sciences. It brings together publishers from 20 countries from Europe, Asia, and the Americas. The database contains nearly 8.5 million articles from more than 2,900 journals, over 300,000 books, protocols, etc. There are also works by several Nobel Prize winners. SpringerLink also contains one of the largest collections of open-access journals in the world (more than 2,200 journals).

Wiley Online Library [75] is a database of the international publishing house Wiley-Blackwell. It is a full-text database of peer-reviewed journals from a range of fields, such as natural sciences, economics, medicine, computer science, or education. The database provides access to more than 8 million articles in more than 1,600 peer-reviewed journals and more than 22,000 e-books.

The last publishing house that also maintains a gigantic repository of journals and articles is the *Multidisciplinary Digital Publishing Institute (MDPI)*. This publishing house specialises in open-access publishing. Currently, MDPI publishes 427 scientific journals, and the number is growing. In 2022, it published 303 thousand articles (compared to 240 thousand in 2021) [76], making it one of the largest publishers in the world and a valuable resource for researchers in most fields.

Many MDPI journals are indexed in prestigious databases. In addition to full open access, one of the drivers of growth is the short time from submission to publication. The average time from submission to publication in MDPI journals in 2022 [76] was 38 days. The high speed of publication, together with the indexing of some journals in prestigious databases, increases the attractiveness of these journals.

2.2.4 Databases providing access to bibliographic information

The second group consists of databases that do not provide access to full-text sources. This type of sources does not contain full texts but only bibliographic information to record the availability of various books and journals for management purposes, e.g., the university's library collection or to decide which subscriptions will be held by the library in the long term. These databases are, therefore, primarily intended for librarians or research management. Among the most important are ERIH PLUS and ULRICHSWEB.

European Reference Index for the Humanities and Social Sciences (ERIH PLUS) [77] is an interdisciplinary database with a greater focus on social sciences and humanities, maintained by the European Science Foundation (ESF). It contains 15 assessment groups (panels), including Educational and Pedagogical Research, Psychology, Linguistics, etc. Unlike other sources in this chapter, ERIH PLUS does not focus on indexing articles but on journals. For this reason, its applicability for researchers is rather limited. The index is, thus, intended more for librarians. This source is interesting from a historical point of view because it played a role in R&D evaluation in the past.

Ulrichsweb Global Serials Directory [78] is a renowned database that provides bibliographic information on periodicals, annuals, irregular sequels and other titles (past or present) from around the world [79] – over 403,000 titles (February 2016) in 977 content categories, from 105,000 publishers in 200 languages. It also includes titles published on CD-ROM, 36,000 periodicals available online, and 5,000 daily and weekly newspapers. Among others, the data include publisher, classification, and ordering information. It is an indispensable resource for librarians, publishers, and marketers. It is published in both online and book formats.

3 Research, development, and innovation

The introductory chapter discussed the basic philosophy of what science is. However, if these insights need to be applied for the purposes of the official evaluation of research organisations or grant programmes, for example, this type of definition is not sufficient. For this reason, these concepts are firmly defined in the legislation in force, particularly in Act 130/2002 Coll., on the Support of Research and Development from Public Funds [11].

According to this Act, research and development in the Czech Republic consists of the following activities:

a) research, being any systematic creative work extending knowledge, including the understanding of a human being, culture, or society, or using methods enabling the confirmation, supplementation, or displacement of acquired information, performed as:
   - basic research – experimental or theoretical work carried out with the aim of acquiring knowledge on the basis or substance of observed phenomena, an explanation of their causes and possible impact whilst using the findings acquired, or
   - applied research – experimental or theoretical work carried out with the aim of acquiring new findings focused on their future application in practice. The results of applied research are directed towards a specific and practical goal.

b) development (experimental development), being any systematic creative employment of research findings or other concepts for the production of new or improved materials, products or equipment, and/or for the implementation of new or improved technologies, systems and services, including the acquisition and verification of prototypes, piloting equipment or equipment for demonstrations.

c) innovation, being the implementation of new or improved technologies, systems, and services into practice, distinguishing:
   - process innovation – the implementation of a new or significantly improved production or delivery method, including significant changes in techniques, equipment and/or software, and
   - organisational innovation – the implementation of a new organisational method in the firm's business practices, workplace organisation, or external relations.

Thus, the Czech legal order overlaps very closely with the internationally recognised categories used for the evaluation of statistical data on science according to the OECD recommendations (Frascati Manual [9], also see Chapter 1).

The central administrative authority responsible for research and development in the Czech Republic is the Ministry of Education, Youth, and Sports of the Czech Republic (MEYS, MŠMT in Czech), except for the areas covered by the Research, Development, and Innovation Council ([11] § 33).

3.1 Legal regulation

The key legal document for research, development, and innovation (R&D&I) is the *Act on the Support of Research and Development from Public Funds* [11]. It regulates the rights and obligations of legal and natural persons, the tasks of organisational units of the State, the tasks of organisational units of the Ministry of Defence and the Ministry of the Interior (hereinafter referred to as "organisational unit of the Ministry") engaged in research and supported from public funds, as well as the conditions of support and the public competition for these public funds. The Act also regulates the provision of information on individual projects as well as research results through the information system for research, development, and innovations (R&D&I IS, IS VaVaI in Czech).

This Act is directly followed by the *Government Regulation on the Information System for Research, Experimental Development, and Innovation* [80] which specifies some details of work with the IS VaVaI that is used to collect, process, provide and use data on research results, as well as other data such as information on research programmes and projects implemented with public funds.

The last important document is the *Act on Public Research Institutions* [81] which regulates the establishment, creation, operation, dissolution and termination of public research institutions, the status and powers of the founder and the bodies of public research institutions, and the conversion of contributory research organisations into public research institutions.

According to this Act, a public research institution is a legal person whose main activity is research, including the provision of research infrastructure, as defined by the *Act on Support for Research and Development*. The main activity of a public research institution shall be to carry out research supported, in particular, by public funds following the conditions for the provision of public support determined by European Union law.

3.2 National Research, Development, and Innovation Policy of the Czech Republic 2021+

The National R&D&I Policy 2021+ [82] was approved by the Government Resolution no. 759 of 20 July 2020 [83] as an overarching strategic document at the national level for the development of research, development, and innovation in the Czech Republic.

The National R&D&I Policy also takes into account the binding and recommending documents of the European Union institutions. Attention is also paid to the operational programmes co-financed from the EU Structural Funds, as they significantly influence the R&D&I base in the Czech Republic and its development. The main objective (or principle) of the National R&D&I Policy is to create a framework for the implementation of measures in the field of R&D&I stimulating the development of a knowledge-based society, leading to further growth in the competitiveness of the Czech economy and the improvement of the quality of life in the Czech Republic. Five sub-objectives have been set to fulfil this main objective; they are based on an assessment of the situation in the Czech Republic and the possibilities of using foreign experience [82]:

- Objective 1: Put in place a strategically managed and effectively funded system of research, development, and innovation in the CR – this objective leads primarily to an effort to increase the diversity of resources spent on R&D&I and to ensure their synergic action with the lowest possible administrative burden on research organisations and individual support providers.
- Objective 2: Support research organisations in creating motivational working conditions and developing human potential across the research and development spectrum.
- Objective 3: Improve the quality and international excellence of research and development in the CR; make the CR more open and attractive for international research and development; and intensify the integration of Czech R&D&I into the European Research Area. In this respect, the priority is primarily the involvement of research organisations in the calls of the HORIZON Europe Framework Programme.
- Objective 4: Promote broader cooperation between the research and application spheres in research, development, and innovation.
- Objective 5: Achieve the expansion of research, development and innovation in businesses and the public sector.

The National R&D Policy is, therefore, a key document used by state authorities (e.g., ministries or support providers) as a basis for designing individual calls for R&D grant projects, and also for evaluating their success.

FOR FURTHER STUDY

In preparing this national policy, several studies written by the Technology Centre of the CAS have been used to describe the current state of the issue in the Czech Republic, as well as the principles used in the deployment of R&D&I policies abroad. These are the main studies:

- Green Paper on Research, Development, and Innovation in the Czech Republic [84],
- White Paper on Research, Development, and Innovation in the Czech Republic [85],
- Book of the Foreign Good Practices in the Implementation of Research, Development, and Innovation Policies [86],
- Innovation Strategy of the Czech Republic 2019–2030 "Czech Republic: The Country for the Future" [87],
- National RIS3 Strategy [88].

For individual research organisations and their research teams, the national policy serves as a document formulating the basic objectives of where research should go. This information is very important when submitting grant projects – they should be consistent in their design with these objectives. For example, Objective 4 indicates that, within individual calls, preference will be given to projects involving both academia and the private sector.

3.3 R&D&I Council

Research, Development, and Innovation Council (hereinafter referred to as "the Council" or "RDIC") is an expert and advisory body of the Government in the field of research, development, and innovation. In particular, *the Council ensures* [11]:

- preparation of the National R&D&I Policy in cooperation with the Ministry of Education, Youth, and Sports and in accordance with international treaties, and its submission to the Government,
- control of the implementation of the National R&D&I Policy in the form of statements on the compliance of research and development programmes submitted by providers with the National R&D&I Policy before the approval of these programmes by the Government,
- preparation of the Methodology for Evaluating Results of Research Organisations and Completed Programmes and its submission to the Government,
- evaluation of the results of research organisations and completed programmes in accordance with the Methodology for the Evaluation of the Results of Research Organisations and Completed Programmes approved by the Government,
- proposals for the members of the Board and the President of the Technology Agency of the Czech Republic and the Grant Agency of the Czech Republic,
- elaboration of the priorities of applied research, development, and innovation in the Czech Republic,
- preparation of regular annual analyses and assessments of the R&D&I situation in the Czech Republic and their comparison with foreign countries, and their submission to the Government,
- the role of administrator and operator of the information system for research, development, and innovation,
- assessment of opinions concerning R&D&I documents submitted to the Government,
- negotiations with the advisory bodies for R&D&I of the European Communities and with the R&D&I councils of the individual Member States of the European Communities and other countries,
- drafting the mid-term forecast for R&D&I support,
- estimation of the total cost of R&D&I covered from individual budget chapters, and proposing their allocation,
- preparation of statements on applications for permission to research human embryonic stem cells or applications to amend such permissions, or applications for

permissions to import human embryonic stem cells, based on proposals from its advisory body, the Bioethics Committee.

Council sessions shall be usually held once a month, however at least once in every three months. The council shall consist of 17 members, including the Chair and Vice-Chairs of the Council. Council members shall hold their office for a period of four years. A member of the Council may be appointed for only two successive periods. Members of the Council may not be represented by other persons. A member of the Council, who is at the same time a member of the Government, may be substituted by his/her deputy, however such a substitute shall not have a voting right. Members of the Council, except for the Chair of the Council, shall be appointed and removed by the Government upon the proposal of the Chairperson of the Council so that leading experts of basic and applied research, development, and innovation are represented.

The *Board of the Council* shall consist of the Chair and three Vice-Chairs. The Board of the Council shall, in particular, manage the activities of the Council in between its sessions, prepare an agenda for the Council's sessions, and coordinate activities carried out by advisory bodies and working parties of the Council. Vice-Chairs are elected from among the members of the Research and Development Council by secret ballot. Candidates shall be proposed by members of the Council. The Board of the Council shall inform the Council, at its next session, of the Board's activities carried out in between sessions. Meeting of the Board of the Council shall be held as necessary, usually once a week. Such meetings shall be presided over by the Chair of the Board, who is a member of the Government. Members of the Board may not be members of the Discipline Committees of the Grant Agency of the Czech Republic or the Technology Agency of the Czech Republic, and members of expert advisory bodies of providers of R&D&I support from public funds for the evaluation of project proposals in public competitions in RDI. It is a long-standing tradition that either Prime Minister or other minister in whose gestion is in the government becomes head of the Board. This is to demonstrate the Government's priority of R&D development as the basis for healthy economic growth in the future.

The Council establishes its *expert and advisory bodies,* in particular:

- expert commissions for the elaboration of priorities of applied research, development, and innovation of the Czech Republic in individual areas of applied research, development, and innovation:
  - the Expert Commission for Life Sciences,
  - the Expert Commission for Physical Sciences and Engineering,
  - the Expert Commission for Social Sciences and Humanities,
- the Commission for the Evaluation of Research Organizations and RD&I Purpose-tied Aid Programmes,

- the Bioethical Commission that prepares documents to address the tasks of the R&D&I Council related to bioethical aspects of R&D, in particular drafting the Council's expert opinions on applications for permission of research on human embryonic stem cells or applications to modify such permission, or applications for permission to import human embryonic stem cells (the Chair of the Bioethical Commission is a member of the Council).

Members of the Council's expert and advisory bodies shall be elected by the Council from among leading experts in the field of R&D&I and shall be appointed and dismissed by the Chair of the Council on the proposal of the Council.

NOTE

The "massive" portfolio of the Council's duties shows that it is an extremely important body in R&D&I management in the Czech Republic, even so important that it is sometimes referred to as an unofficial Ministry of Science. This fact is reinforced by the fact that the Chair of the R&D&I Council is currently the Minister for Science, Research, and Innovation (without portfolio).

3.4 R&D&I Information System

The Information System for Research, Development, and Innovation (IS VaVaI) collects information on research, development, and innovation supported by public budgets in the Czech Republic; it is the only authorised, complete and binding source of this information. The IS currently consists of four active and interconnected public data subsystems (see Figure 7):

- Central Register of R&D&I Projects (CEP),
- Central Register of R&D&I Activities (CEA),
- Register of Information on Results (RIV),
- Register of Public R&D&I Tenders (VES).

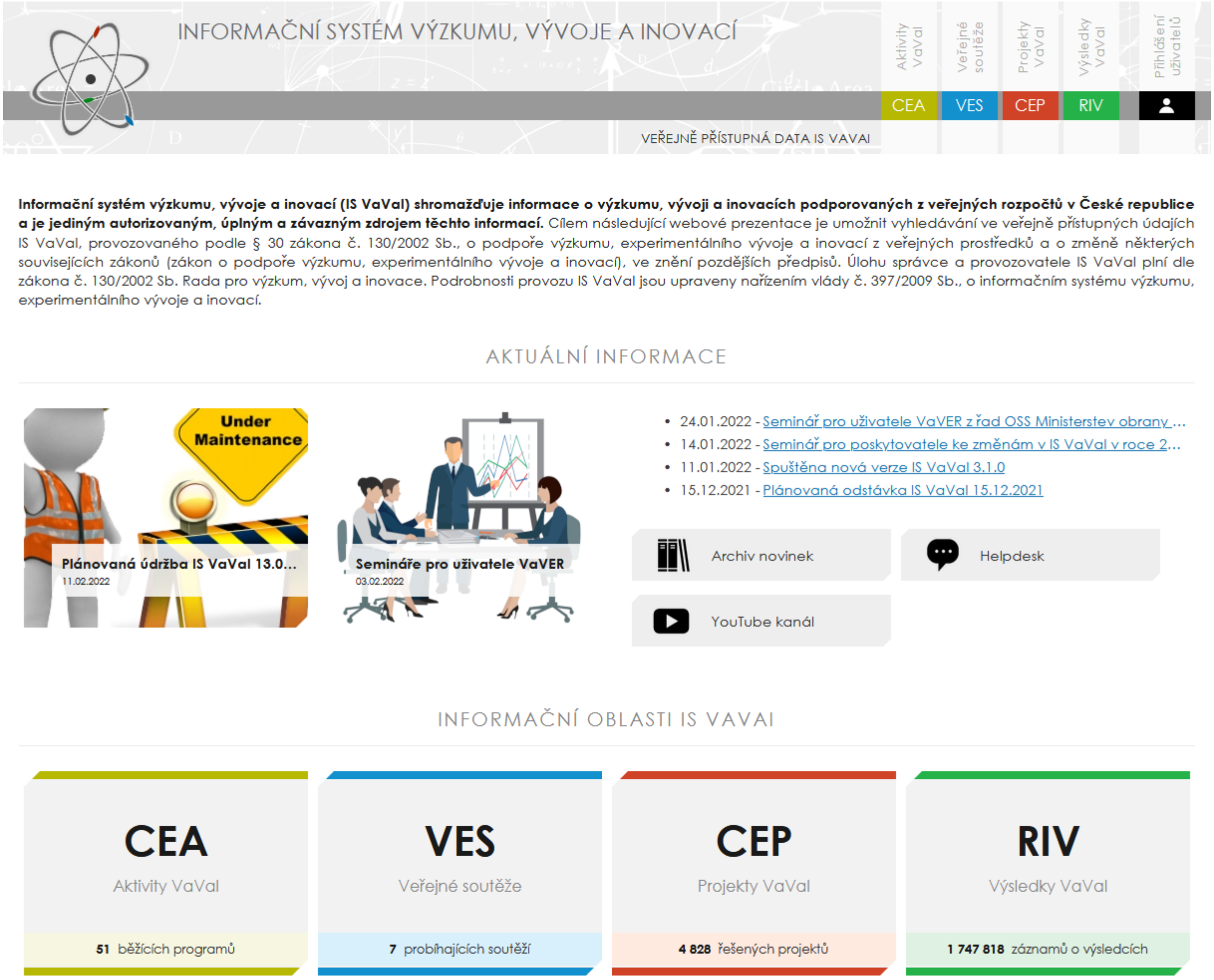


Figure 7: R&D&I Information System [89]

Data from these four parts of the R&D&I information system are used for the following purposes:

- to inform the public and applicants about the announced R&D&I public tenders and their results,
- to inform the public about R&D&I projects and activities supported by public funds and their results,
- to inform other bodies and persons appointed by international treaties about R&D&I results,
- to control the provision and use of special-purpose or institutional support,
- to prepare the state budget draft and to ensure other specified activities of R&D&I providers or bodies under this Act,
- to assess the results of research organisations and programmes and to inform the Government and the public.

The *Central Register of R&D&I Projects (CEP)* contains data on projects for which special-purpose support is provided according to Act No. 130/2002 Coll. Such data is presented in three phases: at the beginning of the project (in the first year of the special-purpose support provision), in the course of the project (in the second to last year), and after the end of the project (in the year following the last year of the special-purpose support provision), or possibly at the interruption or early termination of the project.

For each project, the CEP records data that identify the project, i.e., the name and subject of the project, its beneficiaries, researchers, other project participants and the person responsible for the project, data on the concluded contract or the decision on the provision of support, and the category of research (basic / applied / experimental development / infrastructure / innovation), the provider of the support and the programme to which the project belongs, the duration of the project, the total cost of the project and its division, the amount of the support with an indication of the amount of expenditure from the state budget, the degree of confidentiality of the data, and the evaluation of the project by the provider at the end of the project and a list of the results achieved. The data on results in the CEP are linked to the data in the RIV.

The *Central Register of R&D&I Activities (CEA)* contains data on the provided R&D&I support, namely on the:

- beneficiaries of support and the amount of support provided for specific university research, long-term conceptual development of the research organisation, and their international R&D&I cooperation,
- providers of support and the amount of support for the implementation of R&D&I programmes, including detailed data on R&D&I programmes, and the implementation of groups of grant projects,
- providers of support and their expenditure on securing public R&D&I tenders or public procurements, on financial awards for outstanding results in R&D&I or on financial awards for the promotion and popularisation of RDI,
- expenditures for the activities of the Council, the Grant Agency of the Czech Republic, the Technology Agency of the Czech Republic, and the Academy of Sciences of the Czech Republic.

An essential part of the CEA are the auxiliary registers, namely the Register of R&D&I Programmes (including the subsection of currently implemented programmes), the Register of R&D&I Entities, the Register of R&D&I Support Providers, and the Register of Large Research Infrastructures. The Register of Programmes contains detailed data on R&D&I programmes, such as the name, objectives, data on the support provider and the funding of the programme in individual years, the duration of the programme, data on government approval, data on notification of the support by the European Commission (if notification is available). The Register of Entities contains, in particular, identification data on those entities that may become (or have already been) beneficiaries of support under Act No. 130/2002 Coll. and that are established by state or public administration bodies. At the request of the relevant provider, data on other entities receiving R&D&I aid are also entered in the register. The Register of Support Providers contains a list of those organisational units of the state or local self-government units that may be providers of research support under Act No. 130/2002 Coll. The Register of Large Research Infrastructures contains basic data on large research infrastructures, such as their name and code, information on the umbrella institution, and the identification code of the follow-up project.

The *Register of Information on Results (RIV)* contains all information on the results/outputs achieved in R&D&I research activities with support provided under Act No. 130/2002 Coll., and since 2008 also data on the results achieved by research organisation in R&D&I activities for which no support was provided under Act No. 130/2002 Coll. (e.g., by investigating EU Framework Programme projects, operational programmes or results achieved by the research organisation's own R&D&I activities).

If the result has been achieved through a research activity with the support provided under Act No. 130/2002 Coll., the beneficiary shall submit such results through the provider who provided the support for the R&D&I activity. If a research organisation submits results obtained by carrying out R&D&I activities without such support, it shall submit such results through the provider that may provide institutional support for long-term conceptual development under Section 4(2) of Act No. 130/2002 Coll.

For each result, the RIV records its name and type, or even subtype, if any, the year of application, data on the creators, data on the submitter, the relation of the result to R&D&I activities (e.g., the link to a project registered in the CEP or whether it is a result achieved by carrying out specific university research, etc.). Other specific data identifying the result, depending on its type, are also provided (e.g., name, publisher, and ISSN of the journal that published the result; name, publisher, and ISBN of the publication; patent number and publisher, etc.).

The *Register of Public R&D&I Tenders (VES)* contains data on the announced public R&D&I tenders, the evaluation of public tenders, and accepted projects based on the assessment of these public tenders. For each public tender, the data is segmented into three phases. In the first one, the provider of the support that announces the public tender shall provide data on the public tender, in particular, data on the R&D&I programme, the expected amount of public support being competed for, the expected start of the project, and data on the start and end of the competition and evaluation period, including the method of submission of project proposals. In the second phase, after the public tender is evaluated, the provider shall submit data on the tender results, including the number of submitted projects, the number of projects accepted for public support, and the amount of public support granted as a follow-up to evaluated tenders. In the last phase, the links between the VES and CEP systems are established as the data are transmitted.

4 Support for research, development, and innovation

A necessary condition for implementing any large-scale activity is the elaboration of a project. The word *project* comes from the Latin *proiectum*, meaning plan, draft, scheme. In general, a plan is understood as a developed intention, schedule, or plan of a future activity or its result, e.g., a building, machine, organisation, or activity. It is a time-bound effort directed towards creating a unique result, i.e., a product or service. In R&D, we use the term “research, development, and innovation project” (hereinafter referred to as “project”) that comprises a set of factual, time, and financial conditions for the activities necessary to achieve the objectives in research, development, and innovation. Such conditions are formulated by the applicant in a public R&D&I tender or by the provider in the public procurement notice ([11] § 2).

Broadly speaking, support in research, development, and innovation can be divided into two basic areas, namely institutional and special-purpose. *Institutional support* is intended to support the conceptual development of research organisations that includes [90]:

- ensuring the functioning of the institution as such,
- ensuring stability in the longer term, enabling material and personnel development,
- building and operating infrastructures,
- implementing broader long-term objectives.

In contrast, *special-purpose support* is the provision of earmarked funds to support teams or individuals in R&D projects. Providers of special-purpose support can be divided into four basic groups. The first one includes European Union institutions, such as the European Parliament, the Council, or the European Science Foundation. The second group consists of state grant agencies – the Grant Agency of the Czech Republic, the Technology Agency of the Czech Republic, and the Grant Agency of the Academy of Sciences of the Czech Republic. The latter, however, stopped accepting new projects in 2009. The third group is made up of departmental providers, and the last one comprises universities providing internal support.

4.1 European Union

In the European Union, research support is the responsibility of the European Parliament and the Council and is implemented through the so-called Framework Programmes. Currently the calls for the 9th Framework Programme Horizon Europe are open. This programme is supposed to end in 2027 and is funded with a total of EUR 95.5 billion [91].

The main objectives of the programme are to strengthen Europe’s research base and innovation capacity, support competitiveness and job creation, meet citizens’ priorities, and sustain the EU’s socio-economic model and values.

Another important body supporting research in the European Union is the *European Science Foundation (ESF)*. The ESF is an association of European national agencies responsible for supporting scientific research. It was founded in 1974 and is based in Strasbourg. It currently brings together 78 member organisations (scientific institutions, academies, grant agencies, etc.) from 30 countries and acts as an independent non-profit institution whose members receive contributions from national government budgets. It works closely with the European Commission on scientific interests.

NOTE

Since 1999, the Czech Republic has been represented in the ESF scientific programmes by the Grant Agency of the Czech Republic (GACR) together with the Academy of Sciences of the Czech Republic (CAS CR). The task is to create and strengthen contacts between scientists from different countries and promote cooperation on major projects. At the same time, this cooperation is intended to enable wider use of large and expensive scientific facilities. One of the ESF's priorities has been to define new directions for European research based on the results of joint research [92, 93].

4.2 State grant agencies

Research support in the Czech Republic is enforced by law [11] that regulates the support of R&D from public funds. The support is implemented by state grant agencies as well as individual departments. The following text presents all state grant agencies operating in the Czech Republic.

The most important one is considered to be the *Grant Agency of the Czech Republic (GACR)* which started its activities in 1993. It is an independent state institution supporting basic scientific research in the Czech Republic. Within announced programmes, it provides financial support for research projects to erudite scientists and teams as well as to early-career researchers. It also funds bilateral projects and projects carried out under European international programmes. Around 3,000 applicants apply for GACR grants each year, about one-quarter of which are successful with their applications.

The Grant Agency of the Czech Republic provides special-purpose support for grant projects within grant projects groups [94]:

- *standard grant projects* – support projects focused on basic research,
- *JUNIOR STAR grant projects* – support excellent basic research. The calls aim primarily at early-career researchers. The projects enable such researchers to become independent or set up a new research group, etc.
- *International – Lead Agency grant projects* – LA in the title indicates that the project will be international, supported by several grant agencies (GACR and at least one foreign one). The "lead" principle refers to the evaluation of the grant proposal. Such a grant is evaluated only by the grant agency that is listed as the 'lead' agency in the call, the other participating agencies only take over such evaluations.
- *International bilateral grant projects* – calls are aimed at developing cooperation based on existing bilateral agreements with research agencies in non-EU countries. Such agreements exist with South Korea (NRF – National Research Foundation of Korea), Taiwan (MOST – Ministry of Science and Technology), Russia (RFBR – Russian Foundation for Basic Research) and many other countries.
- *Support of ERC grant applicants* – projects in this call group aim to increase the success rate of applicants for prestigious ERC grants. The programme thus responds to the very low success rate of applications from the Czech Republic.
- *Postdoc individual fellowship – incoming/outgoing* – intended for scholars/researchers at the beginning of their career to carry out research either in the Czech Republic (= arrival of an early-career foreign researcher to the Czech Republic – incoming) or abroad (= departure of a Czech scholar/researcher for a long-term internship abroad – outgoing).
- *EXPRO projects* – their goal is to create favourable circumstances for developing excellent research, to set the standards of excellent science, and to help overcome barriers limiting the success rate of ERC project proposals.

T A Č R Technologická agentura České republiky

Another important national grant agency is the *Technology Agency of the Czech Republic* (TACR) which was established in 2009 based on an amendment to the Act on the Support of R&D from Public Funds [11]. The establishment of TACR was one of the important implementation steps of the Reform of the Research, Development, and Innovation System [95] as it centralises state support for applied research and development that, until then, was fragmented among a large number of providers.

TACR prepares and implements applied research, development, and innovation programmes. These are divided into three groups:

- *TACR Programmes* – grant programmes corresponding to the objectives of the TACR;
- *Departmental programmes* – programmes administered by TACR to the benefit of ministries. Currently, it organises grant programmes for the Ministry of Transport, the Ministry of the Environment, and the Ministry of Industry and Trade.
- *International Programmes and Calls*.

The number of programmes and calls are changeable [96]. Applicants can choose, for example, from the following ones:

- BETA2 – programme of public tenders in applied research and innovation to meet the needs of government authorities;
- THÉTA – programme for the modernisation of the energy sector, including research in the public interest and energy strategies;
- ZÉTA – to support early-career researchers in innovation activities and equal opportunities;
- SIGMA – a complex programme aiming to meet the needs of the society and industry.

Within the *Departmental Programmes group*, the following programmes are organised [96]:

- TRANSPORT 2030 – aims to modernise the transport sector out of regard for sustainability, safety, and societal needs; is organised for the Ministry of Transport;
- ENVIRONMENT FOR LIFE – aims at a healthy and quality environment and sustainable use of natural resources; is organised for the Ministry of the Environment;
- TREND – aims to promote results with potential for competitiveness – new products, production processes and services; is organised for the Ministry of Industry and Trade.

The last state grant agency is the *Grant Agency of the Academy of Sciences of the Czech Republic (GA ASCR, GAAV in Czech)* which was established as an internal body of the Academy of Sciences of the Czech Republic with the mission to distribute funds based on the results of public R&D tenders, allocated for this purpose from the budget of the Academy of Sciences of the Czech Republic and possibly from other sources to provide special-purpose support for grant projects. Based on the amendment to the Act on the Support of Research and Development from Public Funds [11], the acceptance of new projects was discontinued in 2009.

4.3 Departmental support providers

In addition to the state grant agencies mentioned above, research in the Czech Republic is also supported by individual ministries that are referred to as departmental funders. These ministries support R&D&I through the so-called *Programmes*. Individual programmes correspond in their focus to the ministries that announce them, and their contents respond to the current needs of research directions identified by the given ministry.

The programmes are proposed by individual ministries and approved by a resolution of the Government of the Czech Republic. They are subsequently implemented through public tenders. Beneficiaries of support from the Programmes may be research organisations, small, medium, or large enterprises, or innovation clusters.

The following text gives an overview of the current national departmental support providers and their most important running Programmes.

The Ministry of Education, Youth, and Sports (MEYS, MŠMT in Czech)

MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY

The principal programme of the MEYS is the National Sustainability Programme (NPU) which is intended primarily for R&D centres using the so-called "large infrastructures" to ensure the operation of the built centres and to make them competitive with similar centres abroad. A large research infrastructure is defined e.g., by Act 130/2002 Coll., on the Support of Research and Development from Public Funds [11] as: "*a research facility necessary for comprehensive research and development activity with high financial and technological requirements that is approved by the government and established for use also by other research organisations"*. A comprehensive list of such centres, together with further information about them, can be found on the web portal Large Research Infrastructures [97].

Other important programmes of the MEYS are ERC CZ and NÁVRAT (meaning "return"). The first one aims at supporting high-quality research projects that have been successful in the European Research Council evaluation (the so-called ERC grants) but have not been funded due to a lack of funding. The latter is a grant programme designed to fund the return of top R&D&I staff to the Czech Republic and to stimulate the interest of research organisations in them.

The MEYS also supports the so-called *specific university research*. It is a programme under which individual universities are allocated certain funds for the implementation of research activities of their students, especially in doctoral programmes. Universities usually distribute these funds themselves through their own grant programmes.

The Ministry of Industry and Trade (MIT, MPOČR in Czech)

MINISTERSTVO PRŮMYSLU A OBCHODU

MIT specialises in supporting industrial research and experimental development. For this purpose, it organises the TRIO, TREND and THE COUNTRY FOR THE FUTURE grant programmes. The TRIO programme supports industrial research and experimental development with a focus on the development of the Czech Republic's potential in key enabling technologies (KETs), such as photonics, microelectronics and nanoelectronics, nanotechnology, industrial biotechnology, advanced materials, and advanced manufacturing technologies [88].

The aim of the TREND programme is to increase the international competitiveness of companies, especially abroad or on new markets (export). The programme should thus enable enterprises to move up the value chain of customer-supplier relations to the production of products and services with higher added value. However, R&D&I is necessary to achieve this objective.

The COUNTRY FOR THE FUTURE programme targets three main types of activities: 1) the formation of high-tech start-ups, 2) building innovation infrastructures with an emphasis on digital services and artificial intelligence, and 3) putting innovation into practice.

The Ministry of Agriculture (MZeČR in Czech)

The Ministry of Agriculture manages its grant programmes through the National Agency for Agricultural Research (NAZV). Currently, the Department supports grants in only one program called ZEMĚ (meaning "earth"). This programme supports innovative agriculture and forestry through advanced practices and technologies.

The Ministry of Culture (MKČR in Czech)

The main objective of the Programme of Applied Research and Development of National and Cultural Identity "NAKI" (currently NAKI III for the years 2023–2030) is to contribute to the fact that public funds invested in applied research and development in the field of national and cultural identity bring specific economic or other social benefits from their implementation. This objective is pursued through result-oriented sub-objectives related to the main thematic priorities, their subordinate thematic priorities and the definition of applied research and development on national and cultural identity per its current concept.

The Ministry of Health (MHCR, MZČR in Czech)

The Ministry of Health currently supports grant projects in the Applied Health Research Support Programme. Its main objective is to contribute to improving the population's health in the medium and long term, and to meet the current needs of the Czech health sector. Research should lead to improvements in clinical procedures in the diagnostics, treatment, and prevention of diseases. The aim is also to contribute to making the level of research in this area comparable to that of developed EU countries. The programme has three main areas: 1) the origin and development of diseases, 2) new diagnostic and therapeutic methods, and 3) epidemiology and prevention of the most serious diseases.

The Ministry of the Interior (MVČR in Czech)

The Ministry of the Interior implements its Security Research Programme [98] to acquire and effectively develop innovative knowledge, methods, and technologies to enable the security system of the Czech Republic and its stakeholders to meet the current and future challenges arising from the changing realities of the security environment.

Currently, there are four special-purpose support research programmes:

- The Security Research Program of the Czech Republic 2021–2023: development, testing and evaluation of new security technologies (SECTECH);
- Strategic Support for the Development of Security Research in the Czech Republic 2019–2025 (IMPAKT 1);
- The Security Research Program of the Czech Republic 2015–2022;

- The Security Research Program for State Needs in the Years 2022–2027 (SecPro: SECurity PROcurement).

The results of the research should lead to improvements in:

- forensic methods of the police and fire departments,
- the fight against cybercrime and predictions of cyber-attacks,
- protection of the population against terrorist threats, mainly in the area of identifying and soft target protection, and the biometric recognition of persons,
- elimination of the impacts of natural disasters (fires, floods) and the development of crisis management as a complex system,
- detection of dangerous chemical and biological agents and explosives,
- radiation monitoring systems,
- critical infrastructure security,
- environmental security and the protection of the environment in the form of mapping risks and preventing possible threats,
- road safety.

The Ministry of Defence (MOČR in Czech)

The Ministry of Defence currently supports grant projects through the AMBICE programme that aims at ensuring the country's defence capability and at achieving the declared political-military ambitions of the Czech Republic through the development of the capabilities of the armed forces and units of the Ministry of Defence.

5 Research, development, and innovation results

Evaluating scientific performance is one of the most complex problems encountered in RDI. While scientometrics as a science can provide a qualitative basis for performance evaluation, the interpretation of its results is very challenging. Therefore, different countries have independently deployed different systems to assess the performance of individual research institutions, especially those receiving financial support from the state budget.

5.1 Introduction to reporting

As mentioned in the previous chapters, the measurement of science and research (scientific performance) is part of the statistical data collected essentially worldwide, at least within the advanced economies (see Frascati Manual [9]). The collection of data on science and research results in the Czech Republic also had another very important aspect – the emphasis on the fact that research results should be published (unless the result as such is subject to confidentiality, which, however, applies only to a small number of results).

Although it may seem unbelievable, the necessity to publish R&D results just after the fall of communism was not entirely self-evident, as the whole environment was changing significantly. While most research was concentrated in the Academy of Sciences under communism, after the change of the regime, its role as the base for research in the Czech Republic remained, but universities came on the scene and started to develop scientific research activities to a greater extent.

In this climate, information on publication results was collected in the Register of Information on Research and Development Publications in Budgetary and Contributory Organisations (RIP in Czech). This database was operated by the Office of the Government between 1993 and 1995, then it was taken over by the newly established Government Council for Science and Research. As the name suggests, the RIP focused only on organisations that carried out research activities and were financed from the state budget. Thus, the RIP did not have the ambition to cover the whole spectrum of organisations engaged in research at the time, nor did it maintain information on results that did not involve state budget funds. The RIP was also not directly linked to the evaluation of individual research organisations or individual grant programmes.

Functionally, RIP is accompanied by other databases that assign the individual results to specific grants – such a database is referred to as the *Central Register of R&D&I Projects (CEP)* and is still in use today. The CEP consists of data on research projects funded by official public funders (see Chapter 3). In practice, the principal investigator (PI) updates the project information once a year using one of the applications that allow the generation of an export batch to the R&D&I 3.1 information system, such as VaVER. They export the result and send it to the support provider, who then checks the exported file and updates the record in CEP.

In 2004 (based on changes in the legislation on support for research, experimental development and innovation from public funds), the first evaluation methodology was published [99]. It aimed not only to collect information on published R&D results but also to evaluate the individual public research organisations (PROs) that provide the information.

At the same time, the RIP database was replaced by the more modern RIV database (the Register of Information on Results) which has its public part that allows searching results according to selected criteria via the Internet – using the R&D&I Information System web application [89]. An idea of the interconnection of the individual parts of R&D&I IS can be obtained from Figure 8.

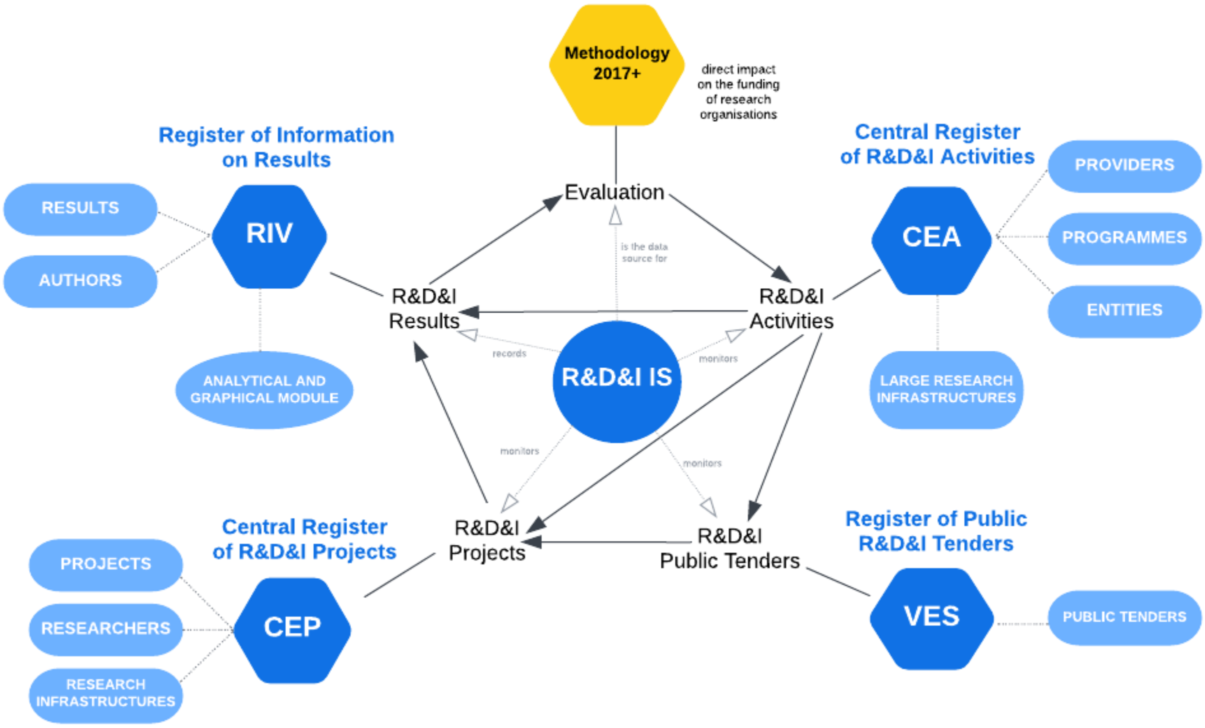


Figure 8: R&D&I IS API [100]

The RIV takes the results already established in the older RIP database and enriches them with additional tracked items. The results are transmitted to individual providers from individual research organisations via RIV export batches. The export batch itself is an XML file with a well-defined structure.

This structure is gradually changing with changing demands on reporting – representing both major changes required by the introduction of new methodologies (at least those introducing major changes to the evaluation system), and minor changes aimed more at clarifying or improving the physical traceability of the reported result.

The export batch consists of two basic parts:

- a header,
- the results.

The header is used to identify the research organisation or its units, if there are any. According to the legislation in force, each organisation unit reports its results separately (creates a separate export batch for each support provider). However, export batch dispatch notes are signed by the research organisation's statutory representative and sent for all the units to all individual providers at the same time.

In the case of a public higher education institution (HEI), the statutory representative is the rector, and the organisation units are usually faculties or special-purpose units with university-wide scope. Each of these units is assigned a five-digit identification number within RIV. The first two digits identify the organisation, the remaining three stand for its units. The header also includes the identifying details of the person who created the batch so that the support provider to whom the batch is sent has contact details for someone who can deal with any potential problems.

NOTE

The results themselves are identified in the batch (and in R&D&I IS) by an identification code, such as: RIV/61989100:27200/12:86078208. The structure of the code is as follows: *RIV / Research organisation ID : Research organisation unit ID / year to which the data collection relates : unique record identifier*.

Another essential piece of information is a type of result (e.g., journal article, proceedings paper, etc.). The choice of the result type determines the further mandatory structure of the collected data. This structure is precisely defined and carefully controlled by automated control mechanisms. For this purpose, the R&D&I Council operates the so-called *web checking service* (WKS in Czech) within R&D&I IS [101], where individual submitters can test whether their batch meets the formal requirements for acceptance.

A batch showing any errors in this checking service will not be accepted by the support provider, and the results cannot be entered into RIV. However, the web checking service is not able to detect so-called *logical errors*.

Requests for changes in the reporting structure are always published at the beginning of the year; the changes are then implemented by individual programme support tools. The only officially supported programme for reporting results is VaVER; however, it does not provide any advanced services to larger institutions with a large number of researchers and hundreds of results to be reported to many different support providers. For this reason, there are other supporting tools that include these superstructure functions.

Especially at universities, but not only there, the OBD system [102] by DERS s.r.o. is popular (OBD is a Czech acronym for Personal Bibliographic Database). In addition to the result report function, it also includes modules for statistical evaluation of publication activity (research project management support) and a list with source and publisher codes that simplify the process of repeated data entry about authors, projects, or publications. There are a number of other systems with similar features (basic reporting and other extension modules), for example, PUBL, used by the University of Ostrava, or ASEP, used by the Academy of Sciences of the Czech Republic.

Therefore, the philosophy of entering results at each research organisation (RO) varies according to the services provided by the used RIV reporting tool, but in general, it can be visualised as in Figure 9. The second important factor is the set-up of the processes in the institution. In simplified terms, the method may be decided by an administrative decision or a less formal agreement on the collection organisation.

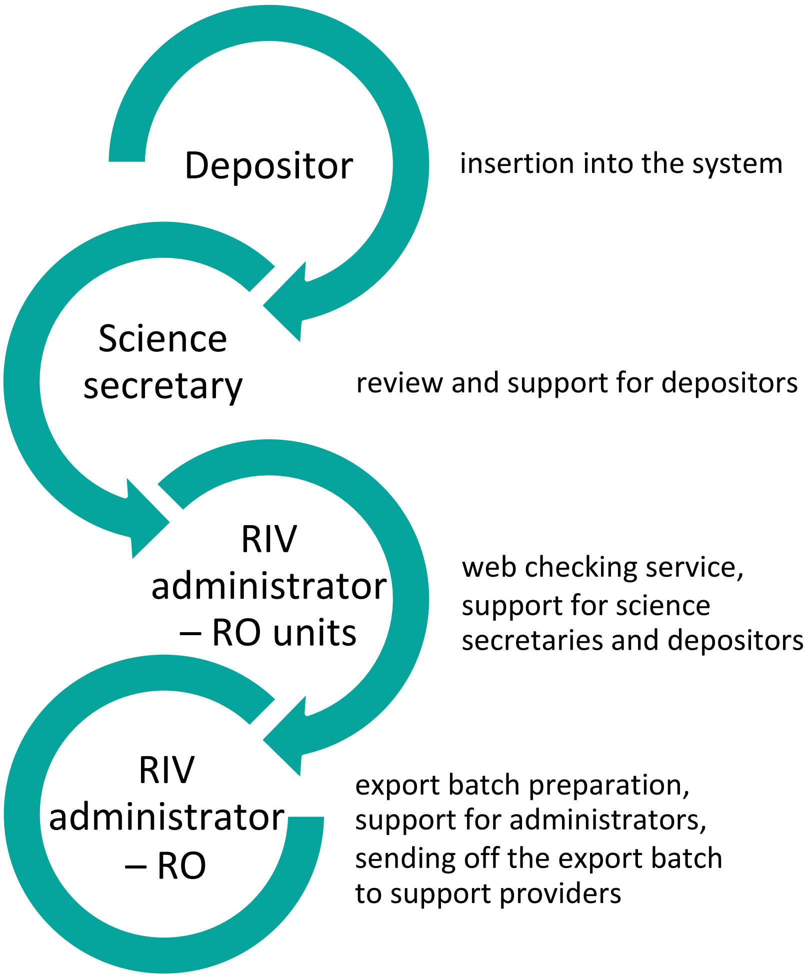


Figure 9: The organisation of data collection for RIV reporting purposes

The ambition of an RO may also play a role. The legal obligation to report results represents only the legislative minimum a research organisation must meet. However, an RO may wish to use such a system more widely, e.g., to facilitate the exchange of information on ongoing research within the organisation, including, e.g., sharing full-text results. Another use may be collecting more detailed information on the research results for internal evaluation of individual RO departments or researchers. These objectives are usually specific to an RO and cannot be anticipated in general terms. Further interpretation will, therefore, be limited to the minimum requirements on reporting specified in the legislation.

Again, in general terms, larger institutions tend to prefer a more formal specification of the reporting process with more checks and support when inputting data. Smaller organisations or their parts may prefer only a two-tier system (depositor – RIV administrator for an RO part) or, in extreme cases, even a one-tier system (e.g., the project administrator reporting for the authors of the institution who have published within the framework of the project).

The moment the RO sends off the export batch with the results, the review and evaluation process begins. It has four official stages, usually preceded by an unofficial stage, carried out by the support provider before the batch data is entered into the R&D&I IS. This unofficial check usually focuses on possible errors resulting from changes in structure, interpretation of individual items, etc. The support provider representative may bring any problem to the attention of the RO representative, who will either make the change themselves or consult the "owner" of the result. Any corrections are made by creating a new version of the export batch. This batch contains not only the changed data but also all other data that have not changed in the original batch. The support provider usually allows some time to implement the changes. However, the time limit cannot exceed the last result delivery date officially set by the evaluation methodology.

The first stage of the evaluation involves checking the reported results against available databases, code lists or, where appropriate, a physical check of the results' existence. The purpose is to detect records that have either been reported incorrectly or do not exist at all. Most of the checks are automated at this stage – i.e., by reviewing the consistency of the entered data against other databases, such as WoS or Scopus.

Problematic results are identified and assigned a comment. The list of such results with notes, in the form of an MS Excel spreadsheet, is sent to RO representatives for comments. They can either accept the exclusion or dispute it.

The solution to the identified contradictions is the subject of the second phase of the evaluation. Long-term experience shows that only a minority of problematic results (approximately 1/3) are usually brought back into play during this phase. It is not possible to add new or edit existing data during this phase. Potential corrections can be made a year later, within the next RIV collection. However, the corrected data will be subject to evaluation according to the rules in force in that year (i.e., not according to the rules in the year the error was made).

The original evaluation method consisted in assigning points to each result according to its type. All scores were added up for the whole RO, and the MEYS then allocated funding based on these scores. Because of the ability to gather all information into one place and process it into one number, regardless of the differences in the types of results, this method was often referred to as “coffee grinder” and was subject to quite substantial criticism.

The advantage of this procedure was its simplicity and the high degree of automation of the evaluation processing. The disadvantages were the constant disputes about the correct scoring for different types of results and the ubiquitous attempt to use the calculation method to obtain the maximum for the RO. It resulted in the inflation of certain result types according to what scored well in a given assessment version. From this perspective, the statement that the system adapts to the way it is measured (and then evaluated) was perfectly valid. Thus, such an evaluation system did not provide a sufficiently good basis for R&D management in the Czech Republic.

The solution to the above-mentioned and many other problems was the adoption of the *Methodology 2017+* (M17+) [103] that fundamentally redesigned the evaluation system. The main change is that M17+ now addresses only evaluation. The issue of funding has thus been separated and remains the responsibility of individual funders. In the case of HEIs, it is the MEYS, but many ministries have their own research institutes they fund directly from their budgets. The Academy of Sciences (AS) allocates funding to its individual institutes.

It is assumed that the allocation of resources is based on evaluation. Paradoxically, this evaluation does not need to be carried out according to the M17+ methodology. For example, the Academy of Sciences has its own system for evaluating its institutions and research teams based on international evaluation panels, which it has used successfully for a long time. However, all other funders currently use the M17+ methodology. The evaluation according to this methodology is carried out in five modules that provide a comprehensive view of different aspects of R&D&I performance in a given RO.

Module 1 – Quality of Selected Results

Within this module, ROs submit the best results they have achieved. Only a limited number of results are evaluated in this way. The number submitted for evaluation by the ROs is derived from the amount of support it has received to achieve them – the minimum is 10 publications + 1 more for every 10 million CZK of the received support.

The results are divided into two categories:

I. First category – basic research results,
II. Second category – applied research results.

The basic evaluation tool is remote reviews. Thus, each result is read and evaluated in terms of quality by selected reviewers from an expert panel related to the article subject.

Module 2 – Research Performance

This module is the closest in principle to the original evaluation system (“coffee grinder”). The basis of the evaluation, in this case, is the bibliometric analysis and various other mainly statistical analyses of, e.g., R&D&I funding, staff composition, etc.

Module 3 – Social Relevance

This module is important especially for ROs that are extensively involved in applied research. The module is designed to determine the impact of such research on society. The evaluation is focused on the contribution of the results to practice, cooperation with the application sphere, impacts on the quality of the life of society, economic benefits, etc.

Module 4 – Viability

Viability means the viability of the RO. It is assessed by evaluating the quality of the management and internal processes of the RO as for:

- research environment – here, the RO organisational chart, personnel management, and available infrastructure are evaluated,
- international collaboration – membership in the global and national research community,
- external funding,
- basic cost and revenue structure in the period under review.

An integral part of the evaluation in the module is a physical on-site visit to the evaluation panel. It will allow panel members to tour the facilities of the RO and learn about the work and results of the individual sites, including the opportunity to discuss with the researchers. The evaluators will thus be able to get a comprehensive picture of the functioning of the RO.

Module 5 – Strategy and Policies

It assesses the quality of the RO research strategy and how it succeeds in meeting the objectives set out in it. The main basis for the evaluation is the self-evaluation report of the RO.

5.2 Typology of R&D&I results

Broadly speaking, R&D results fall into two basic groups:

- publication results,
- non-publication results.

Publication results are regular results, such as articles published in peer-reviewed scientific journals, conference proceedings, or monographs. Non-publication results are of a different nature – they are regulations, methodologies, or prototypes.

Both basic output types represent important parts of basic and applied research. Prototypes, e.g., can advance the quality of the measurement technology needed to conduct research. In applied (corporate) research, on the other hand, publication outputs are of importance – they can, e.g., describe the experience of deploying a technology or a process into practice.

5.2.1 Publication results

Publication results can further be divided into *bibliometrizable* and *non-bibliometrizable*. The difference is whether there is a database for a given type of result from which the sociometric characteristics could be derived. Databases like WoS or Scopus, for example, usually index journal articles and proceedings papers. Such results are, therefore, referred to as bibliometrizable. In contrast, the vast majority of books are not indexed this way, making it impossible to evaluate them objectively. Thus, they are referred to as non-bibliometrizable.

The purpose of publication results may be:

- quick information on new procedures, research, etc.,
- information for the general public or a specialist but not a scientific audience,
- publication of detailed information on a chosen topic using scientific methods,
- demonstration of compliance with the conditions for the award of grant support.

Scientific conferences are designed to provide quick, field-focused, up-to-date information, ideas, and techniques. On the one hand, papers published in the proceedings of such conferences (and papers presented in the plenary sessions of the conferences) go through a refereeing procedure; on the other hand, this procedure is not as complex as in the case of journal publications, and the demands are usually not as high. The total time between submission and publication (if accepted) is usually up to six months. The percentage of accepted papers and the difficulty of the requirements vary from case to case. Low-quality conferences accept most papers that meet at least the basic quality requirements, but prestigious conferences may have such high requirements that they accept only a minority of submitted papers (e.g., 10%).

NOTICE

Especially early-career researchers should beware of so-called *junk conferences*. These are conferences whose purpose is to make the organiser as much money as possible and, therefore, have no demands on quality. To motivate potential participants, the organisers of such conferences connect with large publishing houses (Elsevier, IEEE), promise participants indexing of proceedings in WoS and Scopus databases, the possibility of publishing extended versions of articles in impacted journals, etc. Therefore, before an author invests their time and financial resources to participate, they should check first whether the conference meets their qualitative (or other) requirements, especially when it is the first time, they are attending the conference.

Data published by individual conference organisers should be treated with caution and verified where possible. Claims of indexing by a recognised database are easily verifiable in databases – if previous editions are not indexed, promising that future ones will be indexed is, at the very least, highly optimistic.

The different focus of the papers in the proceedings means that the publication of an article in the proceedings is not necessarily considered the first publication of a research result – the demand on the originality of the output is one of the typical requirements for articles in scientific journals.

In contrast, articles in scientific journals serve to publish comprehensive research results. Compared to a proceedings article, it is the comprehensiveness that is typical. It is not enough to suggest an idea – it is necessary to propose the idea of the article, support it with a set of data that would stand up to critical scrutiny, examine the data using validated methods, and draw a definitive conclusion on the investigated issue based on the obtained data.

Of course, there are different categories of journals that differ in the prestige associated with publishing an article in them. Probably the highest prestige is associated with publishing in Nature and Science that belong to the longest-published journals (since the end of the 19^{th} century) and are among the most cited.

Journals registered in databases such as WoS or Scopus usually meet the strictest criteria in terms of quality check of the published articles. Conditions for being indexed in one of these databases are usually a publishing tradition, and also strict demands on the composition of the journal's editorial board – it should be composed of prominent, scientifically active capacities in the field in which the journal operates.

Journals must also have precisely specified conditions of publication for authors, especially the scientific focus and the method of evaluation of submitted articles. The evaluation is usually carried out in the form of a *peer review*, i.e., by someone from the scientific community who is active in the field and has an independent relation to the author.

One of the most rigorous forms of article quality assessment is the *double-blind peer review*. This evaluation is completely anonymous – the editor sends the article to two or more different reviewers in anonymized form (they do not know whose article they are reviewing). Similarly, the result of the evaluation the author receives is also anonymized. This type of review guarantees the highest objectivity degree. On the other hand, it also takes a great deal of time, especially in "smaller" fields, to find an expert on the article subject who also has the time and is willing to prepare the review. In this case, the time to publication is usually significantly longer.

Meeting the formal requirements alone does not guarantee the journal will be included in the mentioned databases. The decision to index it may also be, to some extent, a matter of luck (e.g., a journal applying for indexing at a time when the database operator is expanding coverage in a given field or geographical area).

The quality of journals, even those indexed in recognised databases, varies. Therefore, journals that are not (yet) indexed may also be of high quality. Problematic, however, are journals that were indexed, but the database operator has, for some reason, discontinued their coverage. A common reason for the termination of indexing is the publisher's transgressions of publishing ethics, such as extremely high self-citation rates, plagiarism, or errors in the peer-review process.

Publishing in non-scientific journals can also be important for scientists. The purpose of publishing in such journals is usually either to build awareness of an issue or to popularise results, usually those close to the application area. This type of article can serve to establish a relationship with potential "customers" for the research. Publishing such results may even be required by some support providers.

5.2.2 Non-publication results

Unlike the previous group, unpublished results are not published, at least not in the same way as, for example, scientific articles. This group includes:

- results intended for the protection of intellectual property (IP), such as patents and utility models;
- results intended to verify the practical feasibility of a technology, product, etc. – prototype, functional sample, pilot plant;
- results of breeding activities – a new variety or breed,
- certified methodologies, specialised maps, software,
- and others.

Creating these types of results is usually linked to the effort to sell or licence the result, i.e., to *commercialise* it. The attempt to obtain or develop a given product type is, therefore, not determined by the system of opposition procedures (except perhaps for certified methodologies) but purely by the willingness of the subject to invest in that type of result.

Thus, an organisation performing development must believe that the investment in a given type of result will yield sufficient economic benefit over a certain period of time to pay at least for its development. A special case may be non-publication results that an entity has committed to develop within a grant competition. From this point of view, however, grant support can be seen as a kind of "subscription", the other economic benefits arising from the results being a kind of bonus that may or may not come.

5.3 Definitions of result types

The previous chapter introduced the basic division philosophy of different types of results, but the methodology of the R&D&I Council defines the individual result types explicitly.

5.3.1 Publication results

J *Peer-reviewed article*

Within this group, the evaluation methodology distinguishes three result subgroups, namely *articles in journals with an impact factor (J_{imp})*, *articles in journals listed in the Scopus* *database (J_{sc})*, and *other articles (J_{oth} / J_{ost} in Czech)*. Formally, the record structure in the RIV is the same for all three article subtypes except for some identification codes. For example, a J_{imp} article requires a so-called WoS code (sometimes also called a UT ISI code), and J_{sc} articles, in turn, require an eID.

Articles in journals with an impact factor (J_{imp}) are those indexed in the Web of Science database by Clarivate [60] and are registered as articles, reviews, or letters. An interesting problem is posed by articles registered in the ESCI database, operated within the WoS index package. Since these articles are registered in WoS, they have been assigned a WoS code, but at the same time, the journals in which they appear have not been assigned an Impact Factor. For such journals, it is not possible to determine the appropriate quartile according to this indicator.

So, the question is whether such an article can be considered an article in a journal with an impact factor (J_{imp}) or not. The answer to this question is yes, but this decision is purely technical as the structure of a J_{imp} best fits the data structure available for this type of article. When reporting, one must take into account that these articles cannot be evaluated in the same way as real J_{imp} articles. If the journal is indexed by Scopus, which is not the rule for this type of journal, it can be evaluated just like a J_{sc}. If, however, it is not registered in Scopus, it will be rated more like a J_{oth}/J_{ost}. The only advantage in this case is that such an article can be better included in citation analyses.

In general, a simple rule should apply for filling in the data: as much information as possible should be filled in, and, of course, truthfully. It is, therefore, recommended to fill in optional fields as well, wherever possible as they can help, e.g., with the traceability of results.

The above applies mainly to links to the web page of the result, e.g., via DOI (Digital Object Identifier). It is a unique code by which any object, assigned such a number, can be traced on the Internet. To access the object, we use a so-called DOI resolver, i.e., a web service that translates the DOI number into a URL referring to the source. The idea is that the DOI number will accompany the object throughout its “life” unchanged. If the location of the object changes, the publisher will have to make a change of address only in one place.

Articles in journals listed in the Scopus database (J_{sc}) use the same rules as articles in journals with an impact factor. As the name of this result type suggests, the condition for inclusion is their indexation in Scopus [63].

All other articles in journals that do not meet the conditions for inclusion in the J_{imp} or J_{sc} type belong to the group of *other articles (J_{oth}/J_{ost})*. A simple distinguishing feature for deciding the article type is the availability of a WoS or eID identifier. If the article can be searched in WoS (using its WoS code), it is a J_{imp}; if it is searchable only in Scopus but not in WoS, it is reported as a J_{sc} with the appropriate eID. Everything else is reported as a J_{oth}/J_{ost}.

NOTE

The DOI number is assigned by individual journal publishers registered with CrossRef [97]. Based on this registration, they are assigned a so-called prefix, specific to each journal, and then a suffix, unique to each article, which results in a DOI number. Below is an example of generating a DOI for a selected article in the *International Journal of Critical Infrastructure Protection*:

Prefix: 10.1016/j.ijcip
Suffix: 2019.03.003
DOI: 10.1016/j.ijcip.2019.03.003
DOI resolver to find the source:
https://doi.org/10.1016/j.ijcip.2019.03.003

BC *Technical book and book chapter*

A technical book is defined by the evaluation methodology as a non-periodical technical publication of a monographic nature in which an author (a monograph) or a group of authors (a collective monograph) publish the results of research and development.

Such a book must be published by a publishing house with an established scientific board and peer-reviewed by at least one generally recognised expert in the corresponding field before publication. The book must have the character of professional literature – it must contain references to literary sources in the text, a list of used literature, a summary in at least one world language, and, if necessary, supporting notes. The book shall be assigned an ISBN.

It can be reported either as a *book (B)* or as a *chapter in a book (C)*. The usual distinguishing feature is the ability to identify the authors of individual chapters. If the authors are listed for the book as a whole, it is reported as a whole (i.e., as the result type B). If each chapter has its own authors, the book is usually reported in parts – chapters (i.e., the result type C). A book is always reported either as a book or as chapters in a book, never as both – this requires some reporting coordination among authors, often from different institutions.

It should also be added that, in terms of evaluation, books are classified as so-called non-bibliometrizable outcomes. Their evaluation is, therefore, more complicated as it has to be done manually. Unlike articles published in journals with an Impact Factor or similar indicator, there is no similar metric for books. A convenient evaluation tool thus remains a remote review by expert panels.

In the case of books published in the Czech Republic, there is a legal obligation (see Act 37/1995 Coll.) [104] to send the so-called *legal deposits* (mandatory copies) to the National Library (NL) and several other libraries. In the past, it was the copies from the NL that were used to verify the existence and quality of the content of the reported books. However, this obligation only applies to books published on a tangible medium and editions published in the Czech Republic. A tangible medium stands for a traditional edition of a book printed on paper or distributed on a physical medium/carrier (e.g., CD, DVD or flash drive).

By contrast, the obligation to hand over the legal deposits does not apply to books distributed purely electronically. In 2016, there was an amendment to the law debated that was supposed to correct this disparity by introducing the obligation of e-deposits (electronic transfer of copies to the NL repository). However, this amendment never went through the legislative process, so electronic copies remain in a legislative vacuum. The NL may, therefore, not have such books available.

Another problem is foreign books, whose publishers are not obliged to send compulsory copies. Such an obligation then applies to a local institution with a function similar to that of the NL in the Czech Republic. The evaluation of such publications can, therefore, be problematic. The current evaluation version addresses this by shifting the obligation to provide a legal deposit to the research organisation that intends to submit such a result for evaluation. It is particularly relevant for evaluation in Modules 1 or 2 in fields where this result type corresponds to publication practices, typically in the humanities.

So, what is and what is not a technical book according to the methodology? First, what *is* a technical book [105]:

- monographs,
- scientifically compiled encyclopaedias and lexicons,
- critical editions of works of art, if accompanied by a study,
- critical, annotated translations of philosophical, historical and other works, if accompanied by a study.

And now, what *is not* considered a technical book [105]:

- results that have not been assigned an ISBN, have not been peer-reviewed by independent readers, and have not been published by publishing houses with established scientific boards,
- bachelor's, master's, dissertation, or habilitation theses,
- teaching texts (textbooks and coursebooks),
- expert opinions and reports,
- promotional publications, yearbooks, annual reports, etc.,
- common dictionaries, encyclopaedias, translations of works,
- fiction.

As a classic would say: *the complexity of a system is inversely proportional to the number of exceptions it contains*. In this spirit, we need to add one more exception. Books registered in the Scopus database as Book series are not evaluated as books but as proceedings papers according to the methodology. Some are similarly registered by WoS. For this purpose, WoS uses the *Book Citation Index* (BCI). In this case, however, books, in terms of reporting, are usually treated as books.

D *Proceedings paper*

The explanation of journals (J) shows that the crucial difference between the result types J and D is currently the assigned ISBN. However, a further condition needs to be met. According to the methodology, only articles registered either in the Scopus database or in the Conference Proceedings Citation Index (a part of WoS) are recognized as proceedings papers.

V *Research report*

The methodology currently supports two types of research reports – the *research report (V)* and the *research report summary (V_{summ} / V_{souhrn} in Czech)*.

Type V is intended for research reports that contain classified information according to a specific legal regulation. The most common are Act 148/1998 Coll., on the Protection of Classified Information, Act 412/2005 Coll., on the Protection of Classified Information and Security Eligibility, or Act 240/2000 Coll., on Crisis Management. Such a report, in order to be reportable, must be required by the support provider within a given grant. A research report containing classified information must, therefore, be requested explicitly by the funder as an output of the project.

By contrast, a research report summary (V_{summ}/V_{souhrn}) is intended for results of mainly applied research carried out under contract with (usually) a commercial entity. This type of research is referred to as *contract research*. Such a report has to be handed over to the ordering party, which has to be confirmed with a protocol. Contracts that do not require the implementation of research activities, such as routine laboratory measurements, do not fall into this category.

O *Other results*

Other results are outcomes that do not fit the definitions of other result types. They are not scored, so the usefulness of reporting them is, therefore, at least questionable. Some researchers report them in RIV to demonstrate an activity, usually not taken into account by RIV in the context of R&D tasks (e.g., popularising research results etc.).

5.3.2 Non-publication results

P *Patent*

The evaluation methodology states that a patent is an invention granted a patent certificate by a relevant patent office. In the Czech Republic, it is the Industrial Property Office that operates based on Act No. 527/1990 Coll., on Inventions, Industrial Designs, and Rationalization Proposals [106]. In the case of the so-called European patents, these are granted by the European Patent Office (EPO) according to the rules defined by the European Patent Convention (EPC).

Patents are only reported to RIV after the entire patent-granting process has been completed (the patent has been granted). From the point of view of evaluation, the advantage of a patent lies in the relatively simple possibility to measure objectively its contribution or deployment in practice. For commercial deployment of the subject matter of patent protection by an entity other than the patent owner, the law requires the conclusion of a licence agreement and its registration with the patent office. Such an agreement is usually concluded for a fee.

Thus, a by-product of this process is an indicator describing the commercialisation of a patent-protected research result that can be used for evaluation purposes. For this reason, this type of information is collected in RIV as well.

Since the commercialisation of a result occurs over time, the initial RIV information on the grant of a patent provides only partial information. The evaluation methodology, therefore, requires, in the case of patents, an annual review of the record for five years with an update of the economic impact of the patent, i.e., if the patent has been licensed during a given year. Changes in patents are reported as part of the so-called correction batch, together with all other records that the research organisation needs to correct in RIV.

Z *Variety, breed, pilot plant and verified technology*

A *variety (Z_{var} / Z_{odru} in Czech)* is a result protected under the Act No. 408/2000 Coll., on the Protection of Plant Variety Rights [107].

The result type *breed (Z_{bre} / Z_{plem} in Czech)*, in turn, must be registered in a studbook as per the requirements of Act No. 154/2000 Coll., on Breeding, Stirpiculture, and Record Keeping of Farm Animals [108].

The evaluation methodology defines a *pilot plant (Z_{pilot} / Z_{polop} in Czech)* as follows: the purpose of a pilot plant is to verify the results of research and development carried out by an author or a team of which the author was a member. It is a verification of the functionality of laboratory procedures on a larger scale, e.g., to determine properties, failure rates and other parameters necessary to put a new system into operation. A pilot plant must be accompanied by at least the equipment design or construction to enable its production in large quantities (mass or serial production). A condition for its recognition is the novelty of the process. Modification or extension (innovation) of an existing plant does not fulfil this condition.

A *verified technology (Z_{tech})* is a result similar to a pilot plant, but in contrast, it focuses on verifying a process or technology. A mandatory part of a verified technology is a protocol for verifying the immediate application of the result in the production process (evidenced by the conclusion of a contractual relationship).

F *Utility model and industrial design*

The evaluation of *utility models (F_{util} / F_{uzit} in Czech)* and *industrial designs (F_{ind} / $F_{\text{prům}}$ in Czech)* is similar to the evaluation of a patent (P) – they are not evaluated until accepted by the Industrial Property Office. In terms of time, granting a utility model or industrial design is faster than granting a patent. Therefore, the procedure is often that the research result is first protected by a utility model or industrial design, thus ensuring at least some (minimum) level of protection, and then a patent is applied for.

G *Prototype and functional sample*

A *prototype (G_{prot})* is a functional industrial product manufactured in a single version to verify the design characteristics in practice. The condition for recognizing a prototype in RIV is the novelty and uniqueness of the design, evidenced by the technical documentation.

A prototype is expected to be followed by a testing series or mass production. If the research result is to be a single device with no expected further series production, we speak of a *functional sample*. It can be the development of a new measuring instrument or a laboratory device with new and unique characteristics. The novelty of the device must be substantiated by its technical documentation.

H *Results implemented by the provider*

This type of results includes the results of research and development that, without major changes (except for those of a legislative and technical nature required by the introduction into a given regulation), are projected in the adoption of a binding regulation (law, standard, regulation, etc.). The H category distinguishes R&D results according to where they are projected.

Results projected into legislation and standards (H_{leg}) – such R&D results are reflected in laws, decrees, or technical standards. In the case of a standard, there is a condition of approval by an authorised standardisation institute that is authorised to issue standards.

Results projected into guidelines and other non-legislative regulations that are mandatory under the relevant provider (H_{nonleg} / H_{neleg} in Czech) – these directives are not legislative – they are adopted by the provider and are binding within the department. It is assumed that for this type of result, the provider is a specific ministry, so the result should be published in their Bulletin.

Results projected into approved strategic and policy documents by state or public administration bodies (H_{strat} / H_{konc} in Czech) – this type is highly specific; it is a result that has demonstrably been used in developing specialised R&D&I policies and designing long-term R&D&I programmes.

N *Certified methodologies and procedures, specialised maps with scientific content*

A *certified methodology (N_{met})* is understood as a document containing new procedures that has been approved and recommended for use in practice by the relevant professional certification (accreditation) body. At present, there is no uniform procedure for the certification process of methodologies, so support providers carry out the certification at their best discretion. According to the R&D&I Council [105], the situation in this area should change. The Council should issue a separate regulation on this issue.

Currently, the procedure is usually the following – the author prepares the methodology in the form required by the provider, usually in the following structure:

- a definition of the methodology objective,
- an identification of the target group of the methodology users,
- the methodology itself,
- a summary of the novelty of the procedure,
- a reference list,
- a list of publications that preceded the methodology.

The submitted methodology is evaluated formally and then sent for a peer review (often at the expense of the applicant for the methodology certification). In case of a positive evaluation, the methodology is accepted by a decision of the given certification body and then published in the Bulletin of the given provider.

Depending on who approves the methodology, three methodology subtypes are distinguished within RIV:

a) N_{metS} – methodologies approved by the competent state administration body for the matter in question. This is the most commonly used methodology subtype in practice.
b) N_{metC} – methodologies certified by an authorised body.
c) N_{metA} – methodologies and procedures accredited by an authorised body.

If a methodology does not fall into any of these three subtypes, it is not considered a methodology in terms of RIV. It can be logically justified by the desire to limit "recognised" methodologies to those whose certification or accreditation for deployment in practice has officially been supported by a governmental or a certification/accreditation body. Such methodologies have a better potential for practical deployment and the resulting impacts on society.

A *medical procedure (N_{med} / N_{lec} in Czech)* is a verified complex of activities, from describing the disease to identifying its causes. Based on this knowledge, a treatment method is determined that leads to the restoration of the physiological balance of the organism. A condition for the procedure's recognition is the verification of its effectiveness by clinical testing.

A *conservation procedure (N_{con} / N_{pam} in Czech)*, as defined by the evaluation methodology, is a verified set of activities (materials and technologies) that lead to the salvage, preservation or restoration of a part of a cultural heritage. In this case, the condition for its recognition is demonstrable verification in practice.

As for procedures, a recommendation by a designated authority is the determining factor for recognizing the result. In the case of a medical procedure, it is the Ministry of Health (via its bulletin) or the State Veterinary Administration (depending on whether it is a human or veterinary medical procedure). In the case of a conservation procedure, the determining authority for recommendation is the National Heritage Institute.

The last N result type is a *specialised map with scientific content (N_{map})*. According to the evaluation methodology, this type of result is a synthesis of point, two-dimensional, three-dimensional and, if applicable, temporal information (4D), obtained cartographically or from a geographic information system (GIS), and their contexts, revealed by researching a specific locality.

In order to be recognised, this result type must have "something extra" compared to a conventional map. The relatively unclearly defined boundary between a "conventional" and a specialised map with scientific content has recently led to considerable criticism of this result type by the expert community. To ensure the quality of this type of results, some institutions have these maps professionally examined (e.g., Palacký University in Olomouc). However, such examination is currently not required by the evaluation methodology.

R *Software*

All of us intuitively understand what software is, but if we want to report it according to the requirements of the evaluation methodology, some additional requirements need to be met. The software must be a result of R&D and meet the requirement of novelty. For example, developing a new spreadsheet for general office use cannot be considered software according to the RIV definition, even though it is undoubtedly software in general terms.

Furthermore, software should be licensable. Third parties (other than the creator or the support provider that funded the software) should, therefore, be able to use it as well. Different providers may have additional requirements for this result type. The MEYS, for example, requires that the information about the software includes a link to the software homepage to allow more detailed information about it (e.g., a manual) or even to download it, ideally including the source code. Such a requirement originates from the desire to simplify the process of checking the existence of the result.

S *Specialised public database*

Specialised public databases are defined as structured data on the original R&D results. A database makes the information available as a source for further research or as a product to the end user. A distinctive condition for this type of result is the novelty of the collected data and its public availability.

5.4 Evaluation of R&D results

Evaluating the results and overall success of entire research programmes is not easy, and every country struggles with it to some extent. The implementation of evaluation systems usually includes a certain bureaucratic component in the sense of a "piecemeal" evaluation of individual results or other indicators, such as citations, and an expert evaluation component where the output quality is assessed by a panel of experts in the field.

The expert evaluation component is often dominant abroad. In general, however, it cannot be said that there is a universally valid or widespread evaluation method. National evaluation systems are based on national traditions and change over time as national priorities change or in the context of past evaluation experiences.

The following subsections thus present the assessment systems of the UK, Italy, and France, as those are considered important sources of inspiration for formulating the basic philosophy of the evaluation system used in the Czech Republic.

5.4.1 United Kingdom

Research quality assessment in the UK is carried out at five-year intervals. The most recent evaluation took place in 2021 under the title REF21. The subjects of the assessment are HEIs (Higher Education Institutions), i.e., universities, colleges, academies etc., operating in Great Britain and Northern Ireland.

The research quality carried out by these institutions is evaluated according to the quality of the outputs achieved by individual researchers that work in these institutions. The institution selects the evaluated researchers by itself, according to rules it draws up for this purpose, publishes and submits to the evaluation committee. For each evaluated researcher, a maximum of four outputs achieved during the reviewed period shall be indicated.

The evaluation of each output is based on three main criteria: the output itself (65% weight), the impact on the economy, society or culture (20% weigh), and the environment (15% weight). The assessment is carried out using expert panels – four main panels and 36 sub-panels that focus on various related discipline groups. The main panels approve the basic evaluation rules that are further developed by individual sub-panels to ensure that the evaluation is appropriate to field specifics and publication conventions.

The main panel consists of the main chair and the chairs of the individual sub-panels. It can also be expanded with additional members – these should have international experience or experience in the use, application, and wider benefits of research.

The sub-panel is composed of a chair and individual members (10–30, depending on the scope of the covered topic). The task of the sub-panel is to implement the basic criteria in the evaluation process of a group of disciplines belonging to a given sub-panel. Based on this "interpretation" of the criteria, the sub-panel then evaluates the submitted results. For the purposes of the evaluation, the sub-panel may require the participation of other persons who act as evaluators. When assessing the results, they have the same rights as regular members of the sub-panel, but unlike the latter, they cannot actively influence the evaluation method – i.e., the interpretation of the criteria used for the evaluation.

All R&D outputs are evaluated using three basic criteria (output, impact, environment) and awarded a certain number of stars according to their quality (see Table 3). There are also formal requirements for the submitted results [109]. For example, results such as journal articles or proceedings papers must be open access.

Table 3: Assessing the level of result quality in the UK [110]

Star level	Description
4*	world-leading in terms of originality, significance, and related factors
3*	internationally excellent, but not up to the highest standard
2*	internationally recognized in terms of quality
1*	nationally recognized
n/a	below the standard of nationally recognised work / does not meet the definition of research for assessment purposes

The overall rating of an institution is determined by the distribution of results in each qualitative category. An example of such a rating is shown in Figure 10.

Overall rating

eval.	4*	3*	2*	1*	n/a
%	12	37	41	10	0

Output (weighting of 0,65)

eval.	4*	3*	2*	1*	n/a
%	12,8	32,8	43	11,4	0

Impact (weighting of 0,2)

eval.	4*	3*	2*	1*	n/a
%	20	45	35	0	0

Environment (weighting of 0,15)

eval.	4*	3*	2*	1*	n/a
%	0	40	40	20	0

Figure 10: Example of institutional ratings in the REF2014 assessment system [110]

Details about the overall UK research and development assessment framework can be found in REF 02.2011 [110], a description of how each panel is constructed can be found in REF 01.2010 [111], and the assessment criteria for each sub-panel are broken down in REF 01.2012 [112].

5.4.2 Italy

In Italy, the research quality assessment, or VQR (Valutazione della Qualità della Ricerca), is also carried out at five-year intervals. The last evaluation was published at the end of 2021 for R&D results achieved in 2015–2019. The evaluation was carried out by ANVUR (Agenzia Nazionale di Valutazione del Sistema Universitario e della Ricerca) and was mandatory for colleges, universities, and public research organisations managed by the Ministry of Education. Other bodies engaged in research activities could also participate in the evaluation, but their participation was voluntary.

The following results were evaluated primarily:

- journal articles and proceedings papers,
- books or chapters in books,
- translations, scientific notes, reviews,
- patents,
- works of art, exhibitions, software, maps, etc.

The 14 panels, or evaluation expert groups (GEV – Gruppi di Esperti della Valutazione), corresponding to 14 discipline groups, were set up for the evaluation. The total number of members of the GEV panels was 450. The individual members were selected based on an open selection process assessing professional erudition, the continuity of scientific work over the last 5 years, or experience in research evaluation, either at the national or international level.

The evaluation applied mainly to the outputs of researchers and academics – academics (except for professors) submitted the 3 best outputs for the evaluation period, and researchers and professors submitted 6. The assessment itself was a combination of:

- direct evaluation carried out by panels using bibliometric analyses (citations, journal impact factor, etc.) – especially in technical fields,
- peer-review evaluation carried out by external experts selected by the GEVs (usually two reviewers appointed per outcome) – especially in the humanities.

Using the approaches listed above, each GEV panel determined the exact assessment method for its own discipline group. The results were evaluated in terms of relevance, innovation, and international importance. Based on these criteria, they were assigned to one of the following categories:

- excellent (weight of 1) – publications in the top 20% of the value scale shared by the international scientific community,
- good (weight of 0.8) – the segment of 60–80%,
- acceptable (weight of 0.5) – the segment of 50–60%,
- limited (weight of 0) – the segment of <50%,
- not assessable – the result does not fit in the type of results assessed in the VQR 2004–2010,
- plagiarism, fraud (weight of -2),
- missing result (weight of -0.5).

Details about the evaluation method and results can be found in the final evaluation report, e.g., for the VQR 2004–2010 [113].

5.4.3 France

The beginning of formal R&D evaluation in France dates to 1989. The evaluation was carried out by the National Committee for the Evaluation of Research (Comité national d’évaluation de la recherche – CNÉR), but it was replaced in 2004 by the independent administrative body

AERES (Agence d'évaluation de la recherche et de l'enseignement supérieur) [114]. This body was responsible for evaluating the entire segment of publicly funded universities and research.

For the implementation of the evaluation, a rather informal evaluation model based on the work of expert evaluation panels was chosen – on-site, i.e., within the research organisation. The purpose was to allow the panellists to get to know the RO environment in detail, including communication with scientists or academic staff. The expert panel was always tailored to the evaluated RO.

The evaluation compared the data gathered in the RO's self-evaluation report with the actual situation, including the evaluation of the quality of publicly funded R&D. The assumption was that, in this way, an objective picture of the quality of the RO's activities could be obtained. AERES has thus become a model for other evaluation organisations in Europe, e.g., the Italian ANVUR. A number of existing evaluation systems have also been extended with some of the tools used by AERES, such as the on-site expert panel evaluation.

Despite such achievements, AERES has been subjected to overwhelming criticism. Due to the situation, AERES was closed down in 2013 and replaced by the High Council for Evaluation of Research and Higher Education (HCÉRES – Haut Conseil de l'évaluation de la recherche et de l'enseignement supérieur).

The main criticisms fell on the evaluation inconsistency between ROs and researchers, non-transparency in appointing representatives to the evaluation panels, difficult comparability of the evaluation results, and several other problems that raised doubts about the evaluation objectivity. The criticism was so strong that the only way to restore confidence in the evaluation was close AERES and replace it with a completely new greenfield evaluation body – HCÉRES. The evaluation is currently carried out at 5-year intervals and is implemented in 5 domains [115]:

Domain 1: Positioning and strategy

1.1: The organisation identifies its position in the national and international environment and analyses its development.

1.2: The RO implements a clear and specific strategy considering its mission and position during the evaluation period.

Domain 2: Organisation and governance

2.1: The RO sets up its internal organisational structure to deliver its activities and implement its strategy.

2.2: Governance of the pursued strategy – governance is based on bodies and management forms aligned with the RO's mission and activities that lead to the strategy implementation. The organisation monitors its activities, implements its strategies, and develops its communication policy.

Domain 3: Key elements in implementing the strategy

3.1: Involvement in the development of university departments and the RO's national role – Together with its university partners, the RO is committed to implementing common policies that reflect on common goals and common actions. The RO has a clearly defined national role in the French research area, with appropriate modes of action.

3.2: Personnel policy – The RO has a dynamic personnel policy that is adapted to its strategy and contributes to its attractiveness as an employer. Staff evaluation contributes to raising the level of all performed activities.

3.3: Cooperation at the EU and international level – The RO contributes to the dynamism of the European research area and to strengthening the influence of France in research and innovation.

3.4: Factors supporting the trust of society in the RO – The RO applies a strict scientific integrity policy, ethical deontology, and sustainable development.

3.5: Long-term resource management – The RO has a long-term vision for the development of its resources and means.

Domain 4: Activities and results

4.1: Research – The RO ensures the dynamism and development of its research activities and implements the focus of its scientific policy.

4.2: Innovation – The RO follows its innovation policy and evaluates its success.

4.3: Expertise in support of public policies – The RO performs scientific and professional activities in support of public policies implemented by national, local, European, or international public bodies.

4.4: Impact of science on society – The RO directs its strategy to maximise the impact of R&D on society and assesses its success.

4.5: Supporting activities – The RO relies on effective management processes and support functions.

Domain 5: Strategic directions for the upcoming period

5.1: Taking into account the evaluation of the reference period, the RO proposes an initial vision of its strategic directions for the upcoming period and the main changes to be implemented.

Each domain mentioned above contains one or more sub-domains with their own evaluation criteria. The structure of domains, sub-domains and evaluation criteria thus forms the outline of the RO's self-assessment report submitted to the evaluation panels.

5.4.4 Czech Republic

The evaluation of R&D&I results in the Czech Republic is carried out through the Methodology for Evaluating Results of Research Organisations and Completed Programmes (hereinafter referred to as the "Methodology"). The basic structure of the evaluation modules was introduced in the previous chapter as an introduction to reporting in RIV which plays an important role in the evaluation in the Czech Republic. However, the preceding text does not mention how such evaluation actually takes place.

Partial assessments take place every year, but the full evaluation occurs only once every five years. The annual evaluation is carried out mainly in Modules 1 and 2 (see Figure 11).

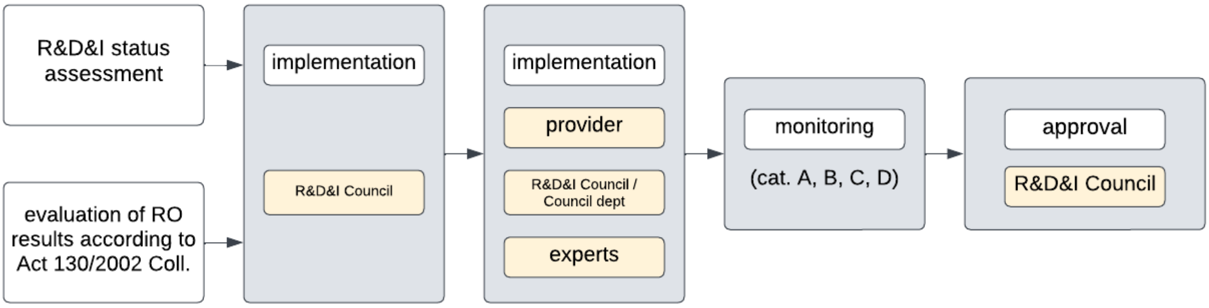


Figure 11: Annual evaluation at the national level [103]

The purpose of such an evaluation is mainly monitoring. Data for the annual assessment are collected primarily through RIV. However, the objective evaluation of an RO regarding the quality of the achieved research is based only on a full, five-year evaluation. The whole evaluation process is illustrated in Figure 12.

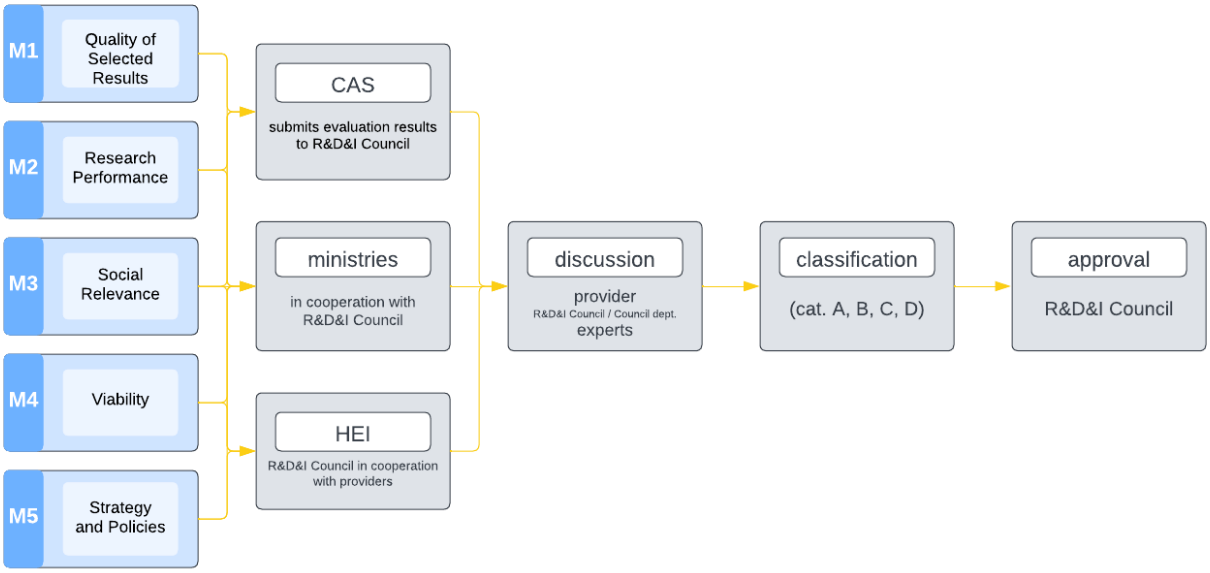


Figure 12: Full 5-year evaluation at the national level [103]

The evaluation results in scaling the ROs into four performance categories:

A – excellent	C – average
B – very good	D – below average

The evaluation results are regularly published on the website https://hodnoceni.rvvi.cz/ [116].

5.4.5 Final notes on R&D evaluation

Chapter 5.4 presented the basics of evaluation systems in four different countries. Although these systems are distinctly different, there are some common elements. Objectively, we cannot say which system is the best and should be copied by other countries without exception because each state addresses a unique mix of problems determined by the state's research environment and the priority setting of the state's governing bodies.

Goals, ideas, or needs can also change over time. Changes in priorities will then inevitably manifest themselves in the evaluation system. Since most R&D evaluation systems used in developed countries are based on several pillars, changes often concern mainly the parameters of the evaluation system in place. The example of France shows that even an evaluation system that is considered established and is imitated abroad can be completely rebuilt because it does not meet the internal requirements of the country in terms of generating quality data for R&D management.

Therefore, the evaluation system itself is often subject to evaluation and subsequent revision. It is thus important to understand the possible evaluation methods and tools available for this purpose, as these are unlikely to change. What may change is the way they are deployed. And this is the point for which the differences of foreign evaluation systems can serve as an inspiration.

6 Reporting of R&D&I results

The previous chapters discussed the typology of R&D results and their evaluation method used in the Czech Republic. So, what else is left to discuss? We have not yet described the way of reporting results, i.e., creating result records, their export to an export batch, and their subsequent import into the R&D&I IS (RIV) by the provider.

At first glance, it may seem that reporting, or collecting data for reporting, is relatively straightforward. However, practical experience shows that it is not the case as the purpose of reporting is very diverse:

- it is required by law,
- it is used for evaluation of:
  - ROs,
  - grants,
  - grant programme effectiveness,
- may be used by the RO itself for its internal evaluation,
- can be used for other activities such as information sharing, development of document repositories, etc.

There are strong pressures and different interests to report. Correct result reporting can thus often be a challenge, even for experienced researchers.

This chapter will therefore focus on selected problems and control mechanisms encountered in reporting so commonly that any researcher should be able to address them satisfactorily.

6.1 Publication outputs

Publication outputs include journal articles (J), proceedings papers (D), books (B) or book chapters (C). Their common characteristics is that they have been published by a publishing house, and, within reporting, sufficient information should be collected to locate not only it, but also basic information about their content.

The above requirements thus determine the structure of the mandatory data collected for these types of publications, i.e., title, authors, abstract, keywords, publisher, and information about the publication (e.g., pages).

As for the already mentioned authors – in terms of employment or study relationship to the reporting RO, RIV distinguishes between internal and external authors. The affiliation to the RO is usually indicated directly in the publication. In the RIV record, internal authors are identified by their birth number or, in the case of foreigners employed by the RO, by another similar identity number assigned to them. For external authors, only their first and last name is collected, and in some cases, only the number of authors.

In recent years, authors have been advised to add also the ORCID number wherever possible. The ORCID is a globally recognised identifier of a researcher, so its use should ensure they are not confused with anybody else. In terms of RIV, however, it is not mandatory at present.

More sophisticated systems, such as OBD, allow authors to be selected from a list of codes, often with the option of integrating author information with the internal employee identification (IDM) used to authenticate employees/students to individual services and systems provided by the RO. Selecting an author from the codelist ensures that the necessary author information is always entered correctly, in complete form and in the same way in each publication to which they are assigned. It would be very difficult to achieve such consistency when completing the information manually. The remaining data varies from record to record, so it must be filled in manually.

Journal articles (J)

The ISSN is a mandatory entry, even if the journal is published only electronically and has an e-ISSN. The RIV record allows a distinction between ISSN and e-ISSN, but only the ISSN is mandatory. Therefore, a journal published in both print and electronic versions may have both types of ISSN assigned. For a journal published only electronically, the e-ISSN is filled in the ISSN field, and the e-ISSN field is left blank.

Previous chapters have also discussed the issue of database identifiers, so just note that if such an identifier has been assigned to an article, it should be filled in the record as well:

- WoS code (from Web of Science),
- eID (from Scopus),
- DOI (assigned by the article publisher).

The WoS code and eID can easily be found in the URL of the article record in the appropriate database, see the highlighted URL parts:

- https://www.webofscience.com/wos/woscc/full-record/WOS:**000469812100009**
- https://www.scopus.com/record/display.uri?eid=**2-s2.0-85064013545**&origin=resultslist&sort=plf-f&featureToggles=FEATURE_NEW_DOC_DETAILS_EXPORT:1

The WoS code can also be found in the appropriate WoS record under the Accession Number. The Scopus eID cannot be found in the same way.

The DOI can be found either in the database record or directly in the article. To check the validity of the recorded identifier, we can use the database API:

- WoS: https://www.webofscience.com/wos/woscc/full-record/WOS:**WoScode**
- eID: https://www.scopus.com/record/display.uri?origin=resultslist&eid=**eID**
- DOI: https://doi.org/**DOI**

Again, instead of the bolded parts of the URL, you need to add the given identifier. Once entered into the web browser, the publication record, or in the case of the DOI, the publication itself, should be loaded. If the link is not functional or leads to a different result, the identifier is incorrect and needs to be corrected in the record.

In the latest revisions of RIV, the publication result record has a new optional box - *link to research data*. The box is intended for a URL leading to the dataset used for achieving the result, which responds to the modern trend of supporting open datasets. The principle was first piloted within the Horizon 2020 programme. The terms of the programme directly required all articles produced with the support of this programme to be published in open access mode. However, open access for datasets is required only in certain areas of the programme.

The testing was a part of the Open Research Data Pilot (ORD pilot) [117]. It was set up so that individual calls could specify whether the requirement applies to them or not. The philosophy of the approach is that data should be available if it is necessary to validate the results published in the article or other R&D outputs.

In this way, research data should be FAIR, i.e., findable, accessible, interoperable, and reusable. The aim of the Horizon programmes has been to encourage researchers to publish and share data more widely, which should have a positive impact on the validation of published procedures and the repeatability (replicability) of research. Given the increased availability of data, it should also mean that fewer new datasets will be created in the future, as many measurements will no longer need to be repeated. Researchers will then be able to concentrate on processing such datasets, which should also help to speed up research. The FAIR approach in the context of result publication is visualised in Figure 13.

The published dataset should be stored in a data repository where it should be accessible using a stable URL or, e.g., a DOI (the use of a DOI is not a requirement in this case). And this is the address that needs to be entered into the *link to research data* box.

In the context of the above procedure, a further verification rule can be derived: if the article is supported by a European Framework Programme (such as Horizon Europe), it must be available in open-access mode, which implies that the *publication method* box must be set to A (open access), and logically, the DOI or link to the full text of the result should be filled in to access the article.

By the way, this condition is not enforced by RIV but by the European Commission as the support provider in an EU Framework Programme. In case the article does not meet the set requirements, the publishing costs may not be recognized as eligible by the support provider and may be charged to the RO.

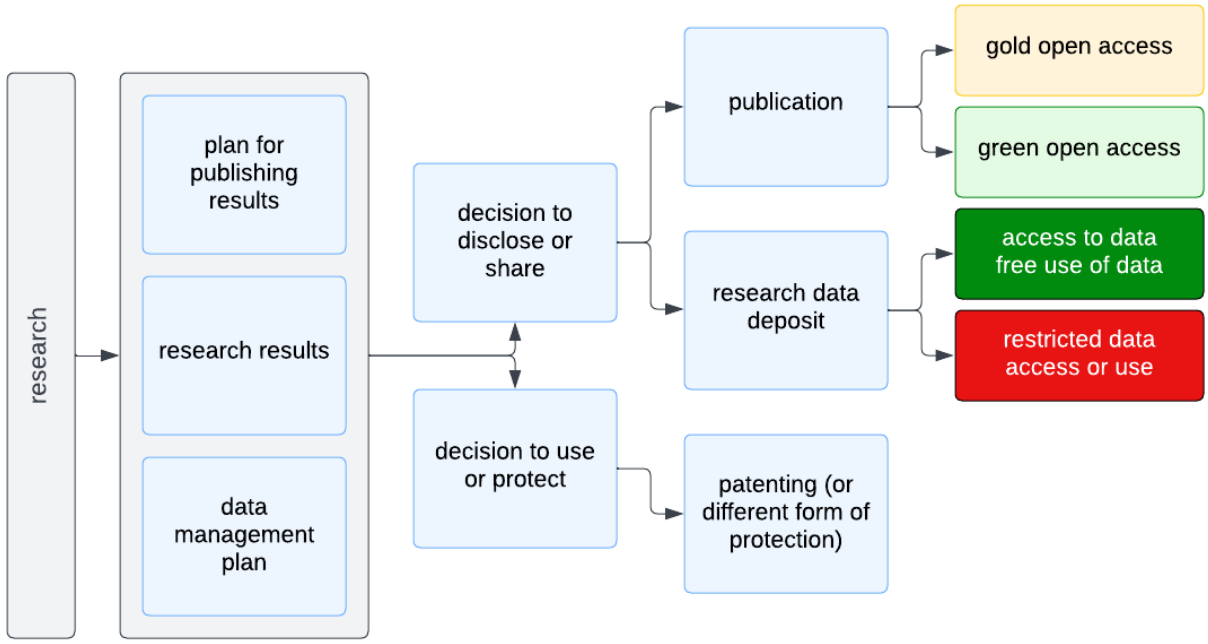


Figure 13: Publication process in Horizon Europe [118]

NOTICE

Did you know that various grant programmes specify primary (main) and secondary outcomes? Such outputs are expected to be achieved in a project (within a given call). But not all types of programmes allow reporting of all types of results.

For example, some grant programmes of the Ministry of Industry and Trade of the Czech Republic are focused purely on applied results, so it is not possible to use their funding to publish non-applied results, even if it is an article in a prestigious impact journal. Costs spent in this way will always be considered ineligible for such grants.

Therefore, if you are involved in a project, first familiarise yourself with its instructions and especially the expected outputs – you will avoid many difficulties.

Proceedings papers (D)

Most of the insights and rules described in the previous text on journal articles are also applicable for proceedings papers. The explanation will therefore focus only on the differences. The basic proceedings identifier is an ISBN. Some proceedings are also assigned an ISSN, but compared to journal articles, it is not mandatory. The ISBN, in contrast, is mandatory.

It can be a real obstacle when reporting some proceedings papers, even those indexed in WoS or Scopus, as most conferences use only ISSN. They do not publish proceedings in print, so publishing takes place in their editorial system with an assigned ISSN.

There are two possible solutions to such a problem, but none of them is quite correct. Since there is only ISSN available, it is technically possible to report such a paper as a journal article, but with the caveat that the associated conference information cannot be reported. It should be noted, however, that since proceedings are not assigned an impact factor or similar indicator (such as SJR), results reported in this way will not be evaluable in this category.

For this reason, we recommend an alternative approach – to keep it as a proceedings paper and to replace the missing ISBN with zeros (0-000-00000-0). This approach is not entirely correct either, but it is better than the previous one in terms of the completeness and accuracy of the reported data.

It is also necessary to add that a proceedings paper in RIV is always associated with a conference, which corresponds with the structure of the mandatory data. If this condition is not met, the result cannot be reported as a proceedings paper. From this point of view, two alternatives are offered - either a journal article, if the proceedings have been assigned an ISSN, or a book chapter.

An interesting box to tick is the form of edition. It can be one of the following:

- C – a storage medium (e.g., CD, DVD or flash drive),
- E – electronic/online version,
- P – printed version.

It shows how the paper or the whole proceedings was published. But if we choose the E form (i.e., electronic version), we should also fill in the DOI (if assigned) or a URL. Both should provide access to the full text of the paper.

The last requirement for a proceedings paper is a minimum length of two pages. It is related to the definition of the RIV paper format, assuming that a paper shorter than two pages is not fully fledged and cannot present R&D results adequately. Such a paper can be considered an abstract rather than a paper itself. However, abstracts are not collected in RIV.

Books (B) and book chapters (C)

In this case, completing the form is fairly straightforward. In terms of traceability of the result, it is necessary to keep in mind the notes presented in Subsection 5.3.1 on the typology of results. It should be possible to check the record against the corresponding record in the online catalogue of the National Library of the Czech Republic [119], at least for those books registered in the NL. The NL record also contains some additional data, such as publisher, number of pages, and many others.

As for other formal requirements, the book should have at least 50 pages of text and include a literature review. In terms of categorization in the NL catalogue, the record should be classified as a monograph or a collective monograph. If it is categorized as a teaching text (textbook), there may be a problem in evaluation.

Regarding book classification, it should be added that the NL performs it at its own discretion based on a physical examination of the contents of the book. At the same time, however, the NL is not staffed to examine the scientific relevance of a book, i.e., to perform their own evaluation of it. Such a situation can be addressed in various ways. The book abstract/annotation should refer to the book as a monograph, which will provide informal guidance to the librarian. Book publishers often address this problem with cover letters sent together with the legal deposits of the book.

Yet, a book can still be misclassified, in which case a correction should be requested. For NL, however, the partner is not the author but the publisher. Any problems should therefore be solved by the author exclusively through the publisher.

Patent (P), utility model (F_{util} / F_{uzit} in Czech), industrial design (F_{ind} / $F_{prům}$ in Czech), conservation procedure (N_{con} / N_{pam} in Czech) and medical procedure (N_{med} / N_{lec} in Czech), breed (Z_{bre} / Z_{plem} in Czech), variety (Z_{var} / Z_{odru} in Czech)

Although the meaning of each type of result differs, the underlying control mechanism is the same in all cases. The check is performed against the database in which the result is recorded. It determines, first of all, whether the result actually exists, i.e., whether, for example, a patent has been granted or licensed, and also whether the data on its authors in the database correspond to the data reported in the RIV.

The check mainly concerns the authors' affiliations and the number of authors. The most frequent error in the case of patents is, for example, that it has been granted, but the owner is a natural person, not an RO. In such a case, the patent has no link to the RO, so it cannot logically report it in RIV. Therefore, it is not sufficient for the recognition of the result that the originator (owner) of the patent has an employment relationship with the RO.

It is also true that these result types are applied, and reporting them involves more administrative work than reporting publication results. In particular, there is the need to determine the economic and technical parameters of the outcome.

The *technical parameters* describe how a device, innovation, process, etc. (depending on the outcome type) works. The box can also be used to provide information on contracts concluded for the application (commercialisation) of the result.

The *economic parameters* are mainly used to describe the expected impact of the outcome. These may be, for example, direct commercial impacts in the sense of economic benefits from potential sales or licensing. Although the box title implies only economic impacts, other impacts, e.g., on society, can be described here as well, as we can assume that this type of impact will also have an economic side in the future, although it is not possible to estimate how significant exactly.

Practice shows that depositors sometimes tend to underestimate these boxes. Such an approach is not correct, as these outputs are part of the assessment of the social impact module for which this type of information is collected.

Also, since commercialisation is expected for applied results, ROs usually set their own processes for registering such results. For this purpose, they often establish specialised departments ensuring, on the one hand, the collection of such results from their originators and, on the other hand, their commercialisation, i.e., offering applied research results outwards to interested parties from the commercial sphere, e.g., in the form of patent licensing, etc.

The result of the registration is the assignment of a numeric identifier that is a mandatory part of many types of applied results. However, we should keep in mind that the registration process may be complicated by the collaborative nature of the research, i.e., by the fact that more than one RO has participated in its achievement. In such a case, the property rights of the individual ROs need to be resolved in advance. For this purpose, contracts between the ROs may need to be concluded.

If the applied result is about to be achieved in the course of the grant task, the conditions of the grant call often include the conclusion of such contracts before submitting the project. If more than one RO is involved in the result, it is necessary that its registration is carried out by all ROs, not by only one of them.

Due to the commercialisation of the result, it is also necessary to select a possible way of using it by other entities. The following options are supported:

- A – a licence is required for the use,
- N – the use is possible without a licence,
- O – the result has not been used so far,
- P – the use without a licence is possible only in some cases,
- V – the result used by the owner.

The outcome is also categorised by the costs of achieving it:

- A – up to 5 million CZK,
- B – 5–10 million CZK,
- C – 10–50 million CZK,
- D – 50–100 million CZK,
- E – over 100 million CZK.

This figure may be interesting for assessing the effectiveness of the support by comparing the expected economic benefits and costs of achieving the result.

The individual result types also differ in the place where data on them are recorded and can be used for monitoring:

- Czech patents and utility models – Industrial Property Office of the Czech Republic (IPO CZ) – Online Database of Patents and Utility Models [120].

- Foreign patents – checks must be performed against the databases of the individual patent offices.
- Industrial designs registered in the Czech Republic can be found in the Online Database of Industrial Designs [121]. As with patents, industrial designs registered abroad need to be checked against the database of the given patent office.
- In the case of a medical procedure for human treatment, the publication in the Ministry of Health Bulletin is decisive; in the case of a medical procedure for veterinary treatment, approval by the State Veterinary Administration is required.
- As for the variety, the verification is performed in the database of the Central Institute for Supervising and Testing in Agriculture.

For pilot plants (Z_{pilot} / Z_{polop} in Czech), it is necessary to create protocols on the deployment of the process; for verified technologies (Z_{tech}), similar documentation is required for the production process or technology. In the case of prototypes (G_{prot}) and functional samples (G_{func} / G_{funk} in Czech), the customer may be the author's institution, so it is "only" necessary to register the result within the institution and to create a basic technical documentation for it.

Of the remaining resuls types, the certified methodology (N_{met}) is the most problematic one in terms of reporting. Certification of a methodology must be completed before it can be reported. Certification is carried out by the official bodies of individual support providers according to the rules they have set. These rules may be simpler or more complex. The certification process, if successful, results in a decision on the methodology certification and its subsequent publication.

The success of the check is based on the ability to trace whether the methodology was certified, when it happened, what number it was assigned, and where it was published. All these details must be filled in carefully so as not to unnecessarily impede its traceability.

All of the above data are entered in a loose form, so any errors will not be detected by the automated check performed at the level of the RO. The most common problems are: the reporting speed is too fast (the methodology has not yet been certified – the author may have positive feedback from the certification body, but the official act of publishing it may be significantly prolonged according to the publishing rules for this type of document), or that the methodology is not traceable – e.g., the link to the full text is not functional due to a typo in the URL address, or the certification body has been identified incorrectly.

Possible verification of the methodology existence will be "manual", so please allow for it.

6.2 Correcting and deleting results in RIV

As evident from the previous chapters, the reporting process is quite complicated, so it is relatively easy to make mistakes. Even if a result has been reported correctly, it may need to be adjusted in the future. For example, if a patent has been licensed, it should be recorded in RIV for a five-year reference period from granting it.

Errors and claims arising outside the RO, e.g., on the part of the support provider, are a different story. Here, it will depend very much on when the error was discovered, as it can set up a further procedure.

There are four basic scenarios. The error was discovered by:

- the person responsible for reporting the result within the RO,
- the support provider before the export batch was uploaded to RIV,
- the support provider after the export batch was imported into RIV, e.g., during a factual check of the grant implementation,
- the depositor after reporting the record to RIV.

The simplest solution pertains to the first scenario – the error was discovered before it got into RIV. In this case, it is usually sufficient to point out the error to the depositor, or a responsible person can correct it themselves, especially if the solution is obvious. Once corrected, the record is reported as usual, together with the other records. All remaining scenarios are more complicated as the record has already been reported to RIV, so its correction will involve extra administrative steps.

The second scenario describes a situation where the error is discovered by the support provider as part of a check prior to importing the batch into RIV, usually occurring in June. The level of checking varies from provider to provider. Typically, large funders that process the majority of reported results, such as the MEYS, GACR or TACR, do not have the capacity and space to carry out extensive pre-checking. In terms of checking, they focus on formal verification of the result consistency through automated tests of the export batch, and the rest of the errors should be detected as part of the provider's checking activities carried out in the context of grant management, which leads us to the third scenario.

Smaller providers used to perform more detailed checks in the past. Such an approach enables correcting the errors before they get into RIV. The advantage is that the correction can be made in the same year as the data collection. However, we cannot count on the provider's benevolence and superior level of checks. The correctness of the reported results is the depositor's responsibility, and the results should be reported correctly at the first go.

In addition to the automated check, the provider has a web checking service, as do ROs. All export batches must pass through it errorlessly before they get to the provider. It means that errors are not usually detected by the support provider.

There is no requirement for manual control by the support provider, although, from the point of view of the RO, it is preferable if it occurs. The sooner an error is detected, the sooner it can be corrected. If the provider does find errors, they will create an error list and send it to the particular RO for correction, usually with a proposal to delete the result. It is then up to the RO to deal with the errors.

In the third scenario, the error is discovered when checking the grant. This scenario is probably the most unpleasant one for the RO because, in this case, the check has discovered a problem in the grant implementation. Such a problem, if not addressed, can have serious consequences for the RO, including the need to return a part of the provided support. Such a situation can only be solved in two ways – delete the problem record using the so-called delete batch or correct it using the so-called correction batch. Since all batch types are submitted to providers on the same date, usually the next April, the correction can take quite a long time.

In the last scenario, the error is discovered by the depositor. As for possible consequences, it is not a bad option as it does not involve a risk of a sanction. The reason for the update could be, for example, licensing a patent or perhaps registering a proceedings paper in WoS or Scopus (with the assignment of a given identifier that needs to be added to the record).

Corrections, regardless of the reason, are technically implemented in the same way – in the form of a correction batch. The difference between a regular export batch and a correction batch is that the data from the former create new records in RIV, while those in the latter overwrite them. Overwriting a record means its "correction". For this reason, the two types of batches are processed separately.

However, performing corrections is the responsibility of the result depositor. They should notify the person reporting for the RO that such a correction needs to be done and provide the necessary data to do so. But as there is no external entity to enforce the record correction in this scenario, it may be quite difficult to provide such an incentive internally within the RO.

NOTICE

Did you know that R&D results can also be built on already completed projects? However, such an option is available only for two years after the end of the project. The time limit is used for detecting results generated during a project that have not been published or processes of awarding a patent or certifying a methodology that have not been completed by the end of the project.

7 The path to successful publication of results

All findings and results of scientific work should be made public so that other scientists working on the subject can learn about them. Besides publications, such communication can take various forms, such as talks, presentations, or posters at conferences. A *talk/presentation* is a subjective evaluation of the results and must be accepted by the conference organiser. An advantage is the following discussion, as it usually brings an immediate reaction to the presented results. Another way of a subjective result presentation is a *poster*. As in the previous case, it must be accepted by the conference organiser, it offers the opportunity of immediate evaluation and discussion with other experts, and in addition, it provides a potential opportunity to make new contacts or to get involved in projects. In contrast to both previous forms, a *publication* must present an objective evaluation of the results, and its acceptance is based on positive/recommendatory reviews. The main advantage of it is the searchability in various databases and the possibility of readers' feedback, i.e., citations.

7.1 Basic rules for publishing in prestigious journals

The journals indexed in the already mentioned prestigious databases Web of Science and Scopus are of high quality and should be approached with respect. It does not mean, however, that we should be afraid of them and prefer not to publish in them. Publications submitted to such journals are subject to high demands that must be complied with. If so, the chances an article will be successfully accepted are high. An example of a *journal article acceptance process* can be seen in Figure 14.

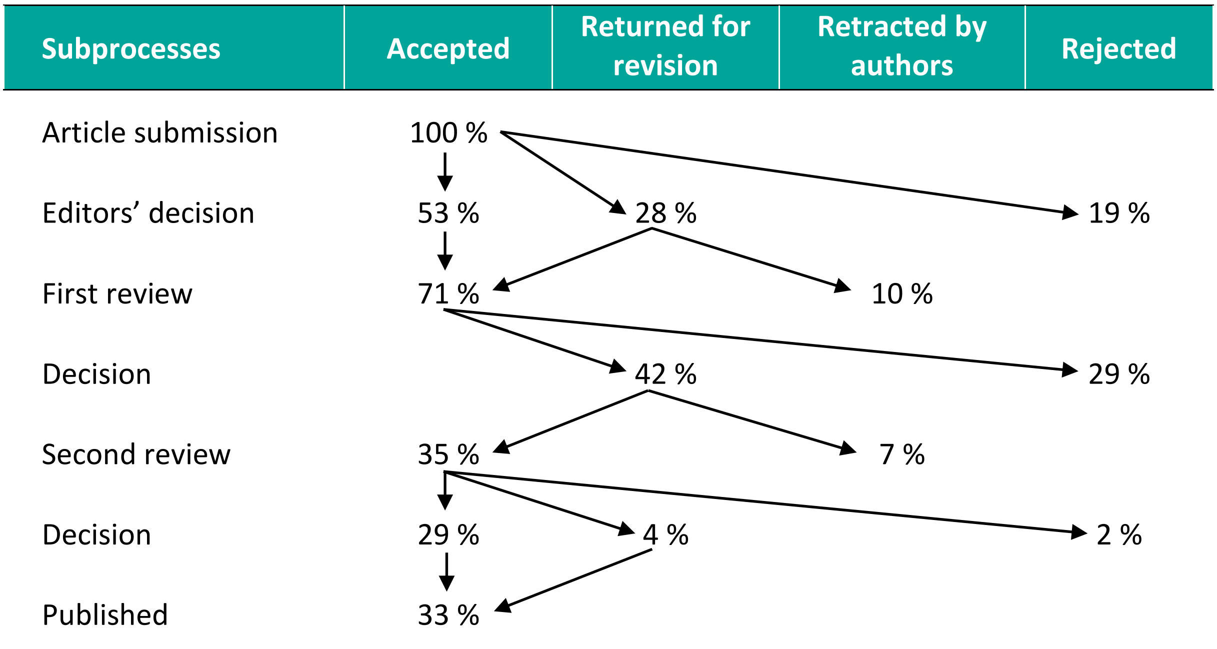


Figure 14: Journal article acceptance process

The timeline of this process is approximately as follows. The editors (including the journal's editorial board) conduct an initial reading to determine if the research content and methodology fits the focus of the journal (1 week approx.). The editors then identify and contact at least 2 reviewers (1 week approx.), who have approx. 2 to 4 weeks to complete their evaluations. Finally, the editors evaluate the reviewers' comments and recommendations and decide to accept or reject the article (2 weeks approx.). Thus, the expected time from article submission to review feedback is 1 to 2 months.

The above timeline should be seen only as indicative. There are publishing houses (e.g., MDPI) specialising in fast publication processes, and there are also journals where reviewers are given significantly more time to write their reviews. In general, the more prestigious the journal, the higher the demands on the quality of the article. It goes hand in hand with changes that have to be made to the article based on the reviews and often the number of rounds of the review process that such an article has to go through before it reaches a publishable state.

After each round of changes, a new peer review must take place to evaluate the new article version. Journal editors usually try to use a reviewer who has already reviewed the article in a previous version, assuming the difficulty of the new review round will be lower since they can focus only on the changes implemented, which speeds up the whole procedure. However, such an approach is not always possible, and another reviewer, for whom the article is new, will need full time to become familiar with it.

When writing a paper, it is important to keep in mind the *basic article writing principles* because respecting them significantly increases the paper's chance of being accepted for publication. These principles are:

- *Originality* – the article must contain a new solution/approach or new way of processing the results.
- *Relevance* – the article must be a significant contribution to the field and help extend what is already known.
- *Status of the work* – the article must contribute to an existing theory and give it a new perspective.
- *Research methodology* – all conclusions must be valid and objective.
- *Clarity, structure, and quality of writing* – the paper must be written in a simple and understandable manner and include a logical sequence of arguments.
- *Theoretical and practical application* – the presented results must be practically and theoretically applicable.
- *Topicality and relevance of sources* – the cited sources must be up-to-date, and their significance must extend beyond national boundaries.
- *Internationality* – the article is intended for a foreign readership and thus must have a global impact.

- *Quality title, keywords, and a well-written abstract* – this last principle is crucial because if it is not clear to the editors at the outset what the article is about, it becomes worthless to them.

Another essential principle is *clear targeting*, i.e., the author must be clear in advance what the article is about and for whom it is intended. For this purpose, it is advisable to search for several potentially suitable journals with the appropriate focus and the required quality level (however, the author must be realistic in their choice) and read at least one issue of each selected journal. After selecting one of the journals, it is essential to study the submission guidelines focusing on the scope and type of publication, word count, citation styles, etc. Once the article is complete, it should be determined to whom (editor, regional editor, subject area editor) and how (via email, as a hard copy, by online submission) it should be sent.

Another important factor influencing the editorial decision is the article structure. The first coherent text the reader comes into contact with is an *abstract* which is intended to capture the basic gist and information of the article text. On this basis, the author must ensure the abstract makes clear the purpose, design and methodology, results and findings, the expected social implications, and, last but not least, the contribution, originality and value, i.e., what is new about the published information and who can benefit from it. The abstract is usually 250 words long and can be written in a structured way. Sometimes an *extended abstract* or *graphical abstract* may be required.

The abstract is usually followed by an *introduction*, the aim of which is to introduce the reader to the discussed issue and to describe the current situation in the field of the research, i.e., why the research was carried out, what its aim and current status is (a short literature review). If the issue or partial results have already been published (e.g., in the form of an abstract or preliminary report on the research results), it is appropriate to mention it in the introduction with a corresponding bibliographical reference. The basic rules for writing an introduction are: define the issue clearly, put the issue in context, explain the choice of the research method, summarise the research results and present the current state of the research.

In all disciplines, it is essential to indicate the *research methodology*. It not only demonstrates the way of conducting the research but also offers the reader guidance on how to proceed in dealing with a similar problem. First, it is necessary to become familiar with the requirements of a particular journal, e.g., the details of the research description. Then, explain the used method (the description of the method informs the reader about its suitability and thus the quality of the obtained results) and justify its choice. If new methods are used, it is necessary to provide their detailed description. Some journals have also acceded to further editing recently, probably to avoid too long articles. They have introduced so-called supplementary (supporting) information that provide detailed descriptions of experiments.

The main part of the paper is the presentation of the *achieved results*. It is a summary description of the main findings that should contain a reasonable quantity of numerical data accompanied by textual interpretation. Specific data results can be presented in the form of a table or chart. In formulating the results, the author must ensure they are clear, unambiguous and understandable. All results should be interpreted in the context of previous publications on the same topic.

A *discussion* and *conclusion* serve as a summary of the basic findings from the achieved results. They form the most complex part, often determining the acceptance or rejection of the whole paper. As the two parts are intertwined, they often form one common part of the paper. While the content of the former is the interpretation of the results, the latter describes the conclusions drawn from the result interpretation. If the results contain any extreme differences, they cannot be obfuscated or distorted, but must be properly explained instead. It is also appropriate to explain the theoretical and practical contribution of the research results and support all conclusions with concrete evidence here.

Once the article is finished and the author is convinced of its quality, it can be submitted (Figure 14). It is good news if the article is returned to the author with a *revision request*, as it means it has entered the publication process. Almost every article is revised at least once. It is then advisable to acknowledge the revision request to the editor and confirm that all the comments have been understood. Once the revision is complete, the article is sent back to the editor with a cover letter. It describes how the article has been revised following the revision requirements and, if not, justifies why.

If an article is *rejected* during the review process, it is a good idea to ask the editor why this was the case. Most editors will be willing to provide detailed comments. It is advisable to use all such comments to revise the text and then offer the improved version to another journal with a similar focus. In some journals, however, the author may appeal against a reviewer's negative opinion or decision with sufficient justification. The most common reasons for rejection include:

- thematic deviation of the article from the focus of the journal,
- qualitative shortcomings, e.g., in readability, length, rigour, sufficient contribution, practical application of results,
- unrealistic, unclear, unintelligible or unverifiable results,
- insufficient theoretical development, i.e., mere description of existing theory,
- unreliable methodology.

7.2 Publication ethics

C O P E

When publishing R&D results, it is necessary to follow certain rules that are either set by law or comprise a part of an unwritten code of ethics for researchers. The following principles are based on existing rules of Elsevier and Committee on Publication Ethics (COPE) [122], the text itself was taken from the website of the Czech peer-reviewed scientific journal *Regional Studies* [123].

Standards for manuscripts

Authors of manuscripts should provide an exact account of the performed work and an objective argumentation for the results. The source data should be presented accurately in the studies. The study should contain sufficient details and references to enable others to reproduce the work. Fraudulent or deliberately incorrect statements constitute unethical behaviour and are unacceptable. Reviews and other journal content should also be accurate and objective, and the editorial decision should be stated clearly.

Data access and storage

Authors may be asked to provide source data used in a study for editorial control. They should be prepared to provide public access to these data (in accordance with the ALPSP-STM statement on data and databases). If possible, they should be prepared to retain these data for a reasonable period after publication.

Originality and plagiarism

Authors should verify they are submitting a fully original work. Works/words of others, if used, must be cited appropriately. Plagiarism takes many forms, including presenting someone else's manuscript as one's own, copying and paraphrasing significant parts of other works (without citing them), or appropriating the research results of others. Plagiarism in all its forms constitutes unethical publishing behaviour and is unacceptable.

Multiple, redundant, and simultaneous publishing

An author should not publish manuscripts describing the same research in more than one journal or primary publication. Submitting the same manuscript to more than one journal simultaneously constitutes unethical publishing behaviour and is unacceptable.

In general, an author cannot submit a study previously published in another journal. Publishing certain types of articles (e.g., clinical guidelines) in more than one journal is sometimes justified if certain conditions are met. The authors and editors of the respective journals must agree to a secondary publication that must reflect the same data and interpretation of the primary document. The primary reference must be included in the secondary publication.

Citing sources

Correct and complete citations of the works of others must always be provided. Authors should cite publications that have had a major influence on the submitted article. Information obtained privately, in conversation, correspondence, or discussion with a third party, may not be used or cited without the express written consent of the source. Information obtained through confidential services, such as reviewer manuscripts or grant applications, may not be used without the express written consent of their author.

Copyright to the article

Authorship should be limited to those who have made significant contributions to the final conception, design, execution, or interpretation of the submitted study. All those who contributed substantially to the article should be listed as co-authors. If there are other people who participated in certain substantial aspects of the research project, they should be acknowledged and listed as contributors. The responsible author should ensure that all relevant co-authors are acknowledged in the study, and that all co-authors have seen and approved the final version of the article and agreed to its submission for publication.

Hazard and human or animal subjects of research

If the work involves chemicals, procedures, or equipment with any unusual hazards associated with their use, the author must clearly identify them in the manuscript. If the work involves human or animal subjects, the author should ensure the manuscript includes a statement that all procedures have been carried out in accordance with relevant legislation and institutional guidelines, and have been approved by the appropriate institutional review board. Authors should include in the manuscript a statement that they have received consent for the experiments from the human subjects used in the experiments. The privacy rights of human subjects must always be respected.

Disclosure and conflict of interest

All authors should disclose any financial or other conflicts of interest that could affect the results or interpretation of their manuscript. All sources of financial support for the project should be disclosed. Examples of potential conflicts of interest that should be disclosed include: employment, consulting, legal ownership, fees, paid professional testimony, patent applications/registrations, and grants or other funding. Potential conflicts of interest should be disclosed at the earliest possible stage.

Fundamental errors in published papers

When an author discovers a significant error or inaccuracy in their published work, they must immediately inform the journal editor or publisher and cooperate in retracting the article or correcting the study. If the editor or publisher learns from a third party that a published paper contains serious errors, it is the author’s responsibility to immediately retract or correct the study or provide the editor with evidence of the accuracy of the original paper.

NOTE

The above rules are intended for authors who want to publish in a scientific journal. But these are not the only rules promoted by COPE. There are also guidelines for editors of scientific journals, the peer review process, publishers, how articles are retracted, and more. A full rule list for all interest groups can be found in the Guidance section of the COPE website [124].

7.3 Visibility and dissemination of R&D results

Once the result is published, it is important to ensure its visibility and dissemination. It is primarily done through the databases and repositories of individual publishers (see Chapter 2), but these are usually chargeable. Then there are also public scientific social networks where results or information about them can be published free of charge. Some of the best known worldwide are ResearchGate or Google Scholar.

ResearchGate [41] is an international project specifically designed for scientists and scholars to facilitate communication, collaboration, and access to scientific literature. The project was founded in 2008 by two physicists (Dr Ijad Madisch and Dr Sören Hofmayer) and a computer scientist (Horst Fickenscher). The basic functions of ResearchGate are:

- creating a personal profile,
- determining the areas of interest of registered participants,
- publishing the full text of publications in the researcher's personal profile (but it is up to the researcher to check whether the full text can be published as per copyright law), including supporting materials such as source data,
- gathering further information on individual publications, e.g., what is cited in them, where they are cited,
- using an online job exchange specialising in positions for scientists and scholars.

The social aspects of the network are very powerful, i.e., the ability to easily connect with other scientists. ResearchGate provides several tools that can be used in this regard. Adding publications to a researcher's profile automatically creates a network made up of co-authors. A newly entered publication is automatically added to the co-authors' profile if they have a ResearchGate profile. Similarly, when cited publications are completed, a notification of the new citation is automatically sent to the cited scientist.

NOTE

Systems such as SHERPA/RoMEO [125] can be used to quickly find out basic information about journals and options available for articles published in them. They contain information about journals' publication policies and self-archiving options.

Individual researchers can be contacted directly within the network, either via a message or by requesting access to texts. ResearchGate can also be used to post questions or challenges, i.e., to communicate with the wider scientific community within a chosen field.

At the same time, ResearchGate acts as a unified information gateway that allows using various sources of scientific literature (PubMed, CiteSeer, arXiv.org, NASA Library, etc.) from one place, including freely available databases of scientific literature made available in open access mode. ResearchGate is currently used by almost 20 million users from 193 countries and contains approximately 135 million publications. 68 Nobel Prize winners also have a profile on this network.

Google Scholar [40] is a Google search technology application focused on academic content. The goal of Google Scholar is to sort articles as researchers do, i.e., to take into account the full text of each article, the author, the publication source in which the article appeared, and how many times it has been cited in other scholarly literature. The most relevant results always appear on the first page.

The Google Scholar index includes public domain content, books, and articles accessible only to users of paid archives, such as the ACM Digital Library and IEEE Xplore. Similar to the Internet search engine, Google Scholar searches the full text of documents, with the additional option to limit search results by author, publisher, publication date, predefined subject headings, or a part of the title of the document being searched.

Google Scholar allows users to create a profile to track citations, other researchers, etc. A major difference from conventional systems, such as Scopus or WoS, is the ability to directly intervene in one's own profile and, e.g., add publications that Google Scholar has not found.

It also differs from other systems in its focus. Google Scholar only searches for resources that are freely available on the Internet (e.g., open access journals or other types of documents such as qualifying papers), which is usually not the focus of purely scholarly systems. Google Scholar can, therefore, help find the impact of a scholar's work that would otherwise be difficult to identify.

ORCID [126] stands for Open Researcher and Contributor IDentifier. It has already been introduced to some extent in the chapter on RIV reporting. The service provides a unique digital identifier of a researcher, but it is only one component of the service. The other services are the researcher record associated with this ID and an open Application Programming Interface (API) to link the service to other services.

It is the combination of all three components that makes the service interesting, perhaps even almost indispensable for researchers and their employers, but also for other "players", such as publishers or various indexing services. It allows the researcher to create their own profile and fill it in directly from other data sources using the existing API.

The service also works in the opposite direction. The ORCID can be used to verify the identity of the researcher, i.e., to integrate it into authentication mechanisms of other systems and services. In this way, it is possible to ensure that a researcher will have only one profile in the linked service. The bonus is that there is no need for a new combination of username and password a service user would have to remember.

Many publishers use it in their editorial systems, as linking it with ORCID allows data exchange between the two systems. While the direction from ORCID usually brings the authentication of the researcher, the opposite direction ensures the deposit of published articles or performed reviews.

The researcher profile may contain the following information:

- basic data – name, short biography,
- employment history,
- education and qualifications,
- awards,
- membership in organisations,
- grants,
- publications,
- review activities.

All sections, except for reviews, can be populated either by manual input or by import from linked sources. The exception is the review section, where individual reviews are always deposited from an external source, so they cannot be entered manually. Completing the section is usually performed by "depositing" the review into ORCID. The deposit has to be initiated in the editorial system of the journal for which the review was prepared or in the Publons service. Such a system must, of course, support the process.

Given the widespread use of ORCID and the relative simplicity of setting it up and filling it in, at least as far as the most important publications are concerned, this identifier can be recommended to every researcher as one of the first activities leading to the visibility of their research outputs. Currently, more than 13.3 million researchers use ORCID. The public researcher profile is available at https://orcid.org/**ORCID**, where the bolded **ORCID** should be replaced by the actual ORCID number of the researcher being searched.

publons

The last tool for visibility and dissemination of R&D results discussed in this chapter is *Publons* [38]. The service emerged in 2012 to make researchers' non-publication results, especially reviews, more visible. The service thus became the first of its kind to allow some form of tracking of this part of a researcher's work.

In 2017, the service was acquired by Clarivate, the owner of Web of Science, and expanded to provide registered researchers with a full profile with all types of tracked outcomes. Through its integration with WoS, the service also gained some citation tracking capabilities, at least those registered in WoS.

Unlike ORCID, Publons offers entering reviews through, to some extent, a manual process – via uploading an article review acknowledgement issued by most editorial boards of reputable scientific journals. Publons verifies such acknowledgements and then registers them in the system where they appear in the researcher's profile.

If a researcher wants or needs to have complete records of all conducted reviews, using Publons is probably the only way to achieve it. Once the reviews have been uploaded into the profile, it is no longer a problem to use the ORCID API to import them into the ORCID profile that otherwise does not support direct editing of reviews.

In late 2022 the service has been fully integrated into Web of Science and its functionality is available only through Researcher profile functions.

7.4 Open access

Open access is a model of scholarly communication that provides immediate, free, permanent and unrestricted online access to publicly funded R&D results. It is defined as an output with no financial, legal, or technical barriers to accessing its content. It is thus a publishing model that makes research information available to readers free of charge, as opposed to the traditional subscription model in which readers gain access to scholarly information by paying a subscription fee (usually through libraries).

NOTE

Basic characteristics of open access [127]:
Immediate = access to the results should be provided at the moment of their publication at the latest (possibly even before publication – e.g., in a preprint repository), it is an access without a time embargo;
Free = access to results should be available free of charge for end users;
Permanent = access should be available in the long term – results must be archived;
Unrestricted = results should not be available only for reading but should be made publicly available to be reused (e.g., by publishing under a free licence).

The initial idea of open access was defined in February 2002 in Budapest within the Budapest Open Access Initiative (BOAI), in which members of the Open Society Institute (today Open Society Foundations) formulated the basic principles, rationale, and strategy for promoting open access in the scientific community. The initiative defines the term *open access* as the free availability on the public Internet allowing any user to read, download, copy, distribute, print, search, or create links to the full text of scientific articles, mine them for indexing purposes, pass them on as data for software, or use them for any other legal purpose without financial, legal, or technical constraints except for those inherent in gaining access to the Internet itself. The only restriction on reproduction and distribution and the only application of copyright protection in this area should be to give authors control over the integrity of their works and the right to proper attribution and recognition. [128]

One of the most important advantages of open access is that it increases the visibility and reuse of scholarly research results. The principles of open access are set out in the *Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities* (2003), signed by many international universities and research organisations.

There are two basic ways of open-access publishing, gold and green. *Gold open access* is based on publishing in peer-reviewed open-access scientific journals. Within this model, open access to publications is provided by the publisher. There may be a fee – the costs of publication, known as the Article Processing Charge (APC), are paid either by the authors or their institutions. Most authors support open access and are willing to pay the costs themselves. In rare cases, the costs are paid by the publisher (e.g., a university press or the scientific community) – this model is sometimes referred to as *diamond open access*.

Green open access is an extension to the traditional way of publishing through scientific journals. The author continues to publish their articles in subscription-based or open access journals, but, at the same time, the full text is stored and made available in an open digital repository. Authors can use the Directory of Open Access Repositories (OpenDOAR) database to find a suitable repository to publish their article or to search the subject literature. Green open access to publications is, therefore, provided by the author, but there are limitations from the publisher. The terms of self-archiving (whether the author can publish the article, what version, and under what conditions) are determined by a Licence Agreement or Copyright Transfer Agreement. [127]

A list of fully open-access journals available worldwide can be found on the *DOAJ (Directory of Open Access Journals)* website. The basic idea behind this web project is to provide a list of as many open-access journals as possible. It was set up by Lund University in Sweden, defining open-access journals as "journals that use a funding model that does not charge readers or their institutions for access".

DOAJ was launched in 2003 with 300 open-access journals. Today, this independent index contains over 19,000 peer-reviewed open-access journals covering all areas of science, technology, medicine, social sciences, arts and humanities. It accepts open-access journals from all countries and in all languages for indexing.

Plan-S is an initiative supported by the cOAlition-S consortium, aiming to shift the way scientific articles are published towards open access as the dominant form of publishing R&D results. The initiative was launched in mid-2018 with the target that no publicly supported articles should be published in any way other than open access by 2021.

Although the 2021 deadline turned out to be too ambitious, changes towards broad support for OA can already be seen in the requirements of various grant programmes (H2020, Horizon Europe) and in the support from various institutions. In the Czech Republic, a deployment strategy for the years 2017–2020 was prepared for this purpose [129]. However, the whole process stopped in 2020 because a full implementation required a change in the law. Once the new or amended law is adopted, the transition process can be expected to resume. The current state in the Czech Republic can be seen in more detail in the Evaluation of the implementation of the Strategy Action Plan [130].

In connection with open access, it is also worth pointing out the need to protect authors from misuse of their works. For example, licences by the US non-profit organisation *Creative Commons (CC)* serve this purpose. They help share works of creative activity in a legal way in order to exploit the full potential of the Internet. The CC licences are tools that allow the public to share and use copyright works in a simple and standardised way, under terms chosen by the author. They operate within the traditional "all rights reserved" setting that are automatically secured by copyright. Thanks to the use of CC licences, there is a massive growth in digital content that can be copied, distributed, modified and altered while preserving all the elements of copyright. In the current version 4.0 offers six types of licences [131]:

- *CC BY (Attribution)*: This licence authorises others to distribute, modify, improve, and create other works based on this work, including commercially, provided they credit the author of the original work. This licence is the most benevolent and is recommended for maximum sharing and use of the licensed materials.
- *CC BY-SA (Attribution-ShareAlike)*: This licence allows others to modify, improve, and create derivative works based on this work, including for commercial purposes, provided they credit the author of the original work, and the new works are licenced under the same terms and conditions, i.e., using the same licence. This licence is often compared to copyleft and open-source software licences. All works derived from your work will use the same licence, so all will also allow commercial use. This licence is used by Wikipedia and is recommended for works that use content of Wikipedia or similarly licensed projects.
- *CC BY-ND (Attribution-NoDerivatives)*: This licence authorises commercial and non-commercial distribution of the work as long as it is distributed unaltered, unmodified and in its entirety, and the author is credited.
- *CC BY-NC (Attribution-NonCommercial)*: This licence allows others to non-commercially modify, improve, and create derivative works based on this work. And while these new works must also be non-commercial and credit the original author, they do not have to be licenced under the same terms and conditions, i.e., use the same licence.
- *CC BY-NC-SA (Attribution-NonCommercial-ShareAlike)*: This licence allows others to non-commercially modify, improve, and create derivative works based on this work, provided that they credit the author of the original work, and that these new works are licenced under the same terms and conditions, i.e., use the same licence.
- *CC BY-NC-ND (Attribution-NonCommercial-NoDerivatives)*: This licence is the most restrictive of the six main CC licences. It only allows others to download your work and

share it with others on the condition that they credit you as the author, but they may not modify the work in any way or use it commercially.

Authors of scientific articles should be familiar with copyright issues and be aware of how their copyrights may be handled by scientific journal publishers. As for property rights, i.e., the rights to use publications, authors usually assign them to traditional publishers. In the Anglo-American environment, this transfer is referred to as the *copyright transfer agreement (CTA)*.

In the context of promoting open access and the possibilities of information and communication technologies, authors want to protect and use their property rights better. It can be done through *author addendums*, i.e., supplements to contracts with publishers. When publishing in open-access or hybrid journals, where authors pay a publication fee, the copyright arrangements between authors and publishers are usually handled by the Creative Commons licences.

Preprint

The last initiative introduced in this chapter is the so-called *preprints*. A preprint is defined as an article published in a preprint repository in a state before the formal peer-review process or even before it is submitted for review. The article is thus available in the state before "print", hence the name preprint.

The advantages of preprints are:

- rapid publication of research results,
- feedback from the broad scientific community before attempting to "fully" publish the article in a scientific journal,
- the possibility of updating the article as needed (up to the point where marked as final),
- self-archiving articles published in journals that support this option.

Preprints are published on specialised preprint servers (repositories), such as arXiv [132] (mathematics, physics, economics), bioRxiv [133] (biology), medRxi [134] (medical sciences) and many others. In some fields, e.g. physics, almost 100% of articles are first published as preprints. For such fields, preprint is an established part of the publishing process. In the humanities, however, the popularity of this publication form is much lower.

Some prestigious publishers, such as PLOS [135], go so far as to integrate the use of preprints directly with preprint services. Thus, PLOS allows an article to be sent for review from preprint repositories (bioRxiv or medRxiv), or conversely, the version sent for review can be deposited in the repository during the submission of the manuscript for review.

Publishing a preprint in a repository also usually allows the author to obtain the DOI, which can be useful for citing the article. Formally, preprint servers function like journals, including being assigned an ISSN, but do not provide peer review.

The advantages of this mode of publication can be demonstrated, for example, in the recent exchange of information on research on SARS-CoV-2 causing Covid-19 disease. Preprints have enabled an extremely rapid exchange of information in the scientific community and have led to a fast knowledge advance in this field.

Information published in preprint articles can be used in further research, but it is up to the person using such results to check their validity. The peer review process provides an assurance the information presented in an article is not obviously erroneous, but it is not available for preprints. The results should therefore be taken as preliminary, and this fact should also be stated in the article when using them.

It should also be added that articles are usually modified during a peer review process, although such modifications in most cases do not change their conclusions (overall message). For this reason, final versions of articles, as published in the scientific journal, should be used for research primarily, not their preprint versions, at least, where possible.

In addition to preprints, some journals also allow their authors to archive articles in the form of *postprints*. The principle is similar to preprint, except that the postprint version includes changes made to the article during the peer review process. The postprint is thus identical in content, but usually not in formatting, to the article published by the journal.

Before uploading a postprint, however, the author should check whether the journal allows this option. In addition to the journal's website, for example, the SHERPA/RoMEO service [125], which indexes journal publication policies, can also be used for this purpose.

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Abbreviations

ACS	American Chemical Society
AERES	Agence d’évaluation de la recherche et de l’enseignement supérieur (= Agency for the Evaluation of Research and Higher Education)
AVČR	Akademie věd České republiky (→ CAS)
BKCI	Book Citation Index
CAS	Czech Academy of Sciences (→ AVČR)
CC	Creative Commons
CEA	Centrální evidence aktivit VaVaI (= Central Register of R&D&I Activities)
CEJSH	Central European Journal of Social Sciences and Humanities
CEP	Centrální evidence projektů VaVaI (= Central Register of R&D&I Projects)
CEZ	Centrální evidence výzkumných záměrů (= Central Register of Research Intentions)
CNCI	Category Normalized Citation Impact
COPE	Committee on Publication Ethics
CSL	Citation Style Language
CWTS	Centre for Science and Technology Studies
CR	Czech Republic (→ ČR)
ČR	Česká republika (→ CR)
DOAJ	Directory of Open Access Journals
DOI	Digital Object Identifier
DCP	Database Citation Potential
DORA	San Francisco DEclaration on Research Assessment
e-ISSN	Electronic International Standard Serial Number (→ EISSN)
EDA	European Defence Agency
EISSN	Electronic International Standard Serial Number (→ e-ISSN)
EPO	European Patent Office
ERC	European Research Council
ERIH	European Reference Index for the Humanities
ESF	European Science Foundation
ESCI	Emerging Sources Citation Index

FAIR	Findable, Accessible, Interoperable, Reusable
FSE	fire safety equipment (→ PBZ)
FVEP	Field Verification and Evaluation Panels (→ OVHP)
GA ASCR	Grant Agency of the Academy of Sciences of the Czech Republic (→ GA AV)
GA AV	Grantová agentura Akademie věd ČR (→ GA ASCR)
GACR	Grant Agency of the Czech Republic (→ GAČR)
GAČR	Grantová agentura České republiky (→ GACR)
GEV	Gruppi di Esperti della Valutazione (= Groups of Evaluation Experts)
GIS	geographic information system
H2020	Horizon 2020
HEI	higher education institution
HSS	humanities and social sciences (→ SHV)
IČO	identifikační číslo osoby (= identification number of a person)
IDM	identity management
IEEE	Institute of Electrical and Electronics Engineers
IF	impact factor
IFwoJSC	impact factor without journal self cites
IP	intellectual property
IPO CZ	Industrial Property Office of the Czech Republic (→ ÚPV ČR)
ISBN	International Standard Book Number
ISI	Institute for Scientific Information
ISSN	International Standard Serial Number
IS VaVaI	Informační systém výzkumu, vývoje a inovací (→ R&D&I IS)
IT	information technology
JCI	Journal Citation Indicator
JCR	Journal Citation Reports
MEYS	Ministry of Education, Youth and Sports of the Czech Republic (→ MŠMT)
MHCR	Ministry of Health of the Czech Republic (→ MZČR)
MICR	Ministry of the Interior of the Czech Republic (→ MVČR)
MIT CR	Ministry of Industry and Trade of the Czech Republic (→ MPO ČR)
MPOČR	Ministerstvo průmyslu a obchodu ČR (→ MIT CR)

MS	Microsoft
MŠMT	Ministerstvo školství, mládeže a tělovýchovy ČR (→ MEYS)
MVČR	Ministerstvo vnitra ČR (→ MICR)
MZČR	Ministerstvo zdravotnictví ČR (→ MHCR)
NAZV	Národní agentura pro zemědělský výzkum (= National Agency for Agricultural Research)
NK ČR	Národní knihovna České republiky (→ NL CR)
NL CR	National Library of the Czech Republic (→ NK ČR)
NP	national policy
NRRE	Národní referenční rámec excellence (= National Reference Framework for Excellence)
OECD	Organisation for Economic Co-operation and Development
ORCID	Open Research and Contributor IDentifier
ORD	Open Research Data
OVHP	oborové verifikační a hodnotící panely (→ FVEP)
p-ISSN	Print International Standard Serial Number
PBZ	požárně bezpečnostní zařízení (→ FSE)
PDB	Program Database file
PRI	public research institution (→ VVO)
R&D	research and development (→ VaV)
R&D&I	research, development and innovation (→ VaVaI)
R&D&I IS	Research, Development and Innovation Information System (→ IS VaVaI)
RDCP	Relative Database Citation Potential
RIP	Registr informací o publikacích výzkumu a vývoje v rozpočtových a příspěvkových organizacích (= Register of Information on R&D Publications in Budgetary and Contributory Organisations)
RIP	Raw Impact per Paper
RIV	Rejstřík informací o výsledcích (= Register of Information on Results)
RO	research organisation (→ VO)
RVVI	Rada vlády pro vědu, výzkum a inovace (= R&D&I Council)
SGC	student grant competition (→ SGS)
SGS	studentská grantová soutěž (→ SGC)

SHV	společenské a humanitní vědy (→ HSS)
SJR	SCImago Journal Rank
SNIP	Source Normalized Impact per Paper
STEM	science, technology, engineering, math
TACR	Technology Agency of the Czech Republic
ÚPV ČR	Úřad průmyslového vlastnictví ČR (→ IPO CZ)
URL	Universal/Uniform Resource Locator
USA	United States of America
USPTO	United States Patent and Trademark Office
UT ISI	Unique Article Identifier
VaV	výzkum a vývoj (→ R&D)
VaVaI	výzkum, vývoj a inovace (→ R&D&I)
VES	Evidence veřejných soutěží ve VaVaI (= Register of Public R&D&I Tenders)
VO	výzkumná organizace (→ RO)
VQR	Valutazione della Qualità della Ricerca (= Research Quality Assessment)
VSB-TUO	VSB – Technical University of Ostrava (→ VŠB-TUO)
VŠ	vysoká škola (= university)
VŠB-TUO	Vysoká škola báňská – Technická univerzita Ostrava (→ VSB-TUO)
VVO	veřejná výzkumná organizace (→ PRI)
VVS	veřejná vysoká škola (= public university)
WoS	Web of Science
WWW	world wide web

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List of figures and tables

About the authors

Full Professor David Řehák graduated from the Military University of Land Forces in Vyškov, majoring in Environmental Economics. Then he continued his studies in the three-year PhD programme Troop and Population Protection, focusing on Modelling and Simulation of Troop and Population Protection Processes, that he completed in 2005 at the University of Defence in Brno. From 2006 to 2009, he worked as an assistant professor at the Institute of Strategic and Defence Studies of the University of Defence in Brno, teaching in the courses for the General Staff, Senior Officers and other professional courses. He was appointed an associate professor in 2012 and a professor in 2021, both in Fire Protection and Safety at the Faculty of Safety Engineering of VSB – Technical University of Ostrava. He currently works at the Department of Civil Protection at the Faculty of Safety Engineering of VSB. He focuses on the topics of critical infrastructure resilience, population protection, risk management, and environmental safety.

Associate professor Pavel Šenovský graduated from VSB – Technical University Ostrava, Faculty of Economics, majoring in Computer Science and Systems Engineering (1999). Then he joined the Institute of Economics and Control Systems at the Faculty of Mining and Geology of VSB as an assistant professor. In 2002, he moved to the Faculty of Safety Engineering, where he still works at the Department of Civil Protection as the Deputy Head of the Department, supervising and teaching several courses focused mainly on computer science. He received his PhD in 2009 and was appointed an associate professor in 2013, both in Fire Protection and Safety at the Faculty of Safety Engineering of VSB. His professional interests include information technology, modelling, and critical infrastructure; he is the author of numerous books and educational texts.

Nela Stebnická graduated from the University of Ostrava, majoring in English Philology and Spanish Philology (2014). She has worked as a lecturer, translator, and proofreader, both in the private sector as well as in academia, holding the posts, for example, of a Language Editor in Advances in Electrical and Electronic Engineering (2015–2017) or a Deputy/Managing Editor in GeoScience Engineering (2020–present). She has been involved in R&D support since 2019 as a university librarian at the Central Library of the VSB – Technical University of Ostrava, since 2022 as the Head of the Science, Research and Education Support Department. She is a co-author and lecturer of a series of courses titled LibGuide: A Library Guide to Academic Writing within the PhD Academy project.

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Young beginning researchers often encounter a problem when trying to work in an environment full of complex rules of operation. They subconsciously feel they should comply with them but, at the same time, do not know how. They obtain a lot of information from their friends, colleagues, or supervisors, but the information is often incomplete and obtaining it is time-consuming. This book is aimed especially at these people, serving as a kind of introduction to the complex environment of science and research, enabling them to adapt much more quickly and effectively.

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