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Frascati Manual and Evolution in the Collection of Data on Work to Create New Knowledge

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Chapter 3

Evolution in the collection of data on work to create new knowledge

Jari Kuusisto, Stephen Flowers

This chapter reviews the development and revision of the collection of data concerning research and development (R&D) by the OECD (Organisation for Economic Cooperation and Development) and laid down in the Frascati Manual. It will provide a detailed summary of the core definitions of R&D activity contained within the Manual and explore how the approach to data collection has been revised over seven editions since the introduction of the Frascati Manual in 1963. The chapter explores how these revisions were made in response changes in the world economy and the new ways of undertaking R&D that continue to emerge. The challenges faced by such approaches to data collection are examined and the chapter concludes by raising a series of issues that may provide directions for further research in this area.

3.1 Introduction

This chapter will provide an overview of the way in which data has been collected on the complex and often uncertain activities of the scientists and technicians who labour to create or develop the new knowledge upon which novel products and services depend. This knowledge is created within a process that has come to be known as Research and Development (R&D). The systematised creation of new knowledge (and the patent system it often relies on) harks back to early industrial contexts, with Thomas Edison arguably being the patron saint of all those engaged in such work. This chapter explores how the OECD (Organisation for Economic Cooperation and Development) developed and revised a system for collecting data on R&D activities within its member nations. It explores how this approach – embodied in a document called the Frascati Manual – was repeatedly revised to reflect the many changes in the economies, industrial structures and political priorities of OECDs member nations. The chapter also explores how, from its initial publication in 1963, changes like the shift to production of services, the central importance of software and the rise of globalisation has resulted in reliable data becoming harder and harder to collect. The chapter also explores the impact of global heating and concludes with an exploration of the potential challenges facing the collection of data concerning R&D in the future.

3.2. Background

The West's obsession with the measurement of Research and Development (R&D) can be traced back to a single seismic event in 1957 – the launch of Sputnik by the USSR¹. Orbiting the earth and transmitting a simple signal for a few days until its battery ran out, this technological achievement by the Soviet communist regime catalysed efforts to better understand the scale and scope of research and development efforts in Western economies. At this time there was a great deal of data on different types of research and development activity but it had yet to be pulled together, and there was no international agreement on how this data should be dealt with so that it could be used for targeted policy actions and international comparisons. The first Frascati manual published in 1963 by the OECD

¹ Chris Freeman, personal communication, July 8th 2008.

(Organisation for Economic Cooperation and Development) was the result of a process that took a broad range of existing data related to research and development across many parts of Western economies and distilled it down to create a better understanding of the level of R&D within those economies. The OECD had been established in 1960 and was the successor to the OEEC (Organisation for European Economic Cooperation), which had been created in 1948 to manage the Marshall Plan, with the aim of stimulating economic progress and world trade (Table 1 shows the member nations of the OECD together with the year of their accession). Arguably, the codification of R&D was an important aspect of that mission, leading to the development of two manuals focused providing guidance on the collection of data concerning Research and Development and Innovation: Frascati Manual (the collection of data on R&D activities, first published in 1963) and Oslo Manual (the collection of data on innovation activities, first published in 1996).

Table 1 around here

The Frascati Manual (so-called as it was first drafted in the Villa Falconieri in Frascati, Italy) defines the statistics related to R&D that are collected on a national level in many countries around the world. It has been very successful and

‘...is not only a standard for R&D data collection in OECD member countries. As a result of initiatives by the OECD, UNESCO, the European Union and various regional organisations, it has become a standard for R&D measurement worldwide. It is also a recognised standard in other statistical domains, such as in education and trade statistics.’

OECD 2015: p6

In this context Research and Development is very much viewed as a necessary precursor to innovation activity, with the development of a greater understanding of the broad landscape of R&D an important factor in enabling a more focused industrial effort and the development of appropriate policy actions. Thomas Edison and the first systematised R&D lab at Menlo Park casts a long shadow in this respect², with the OECD acting to provide a methodology to collect a common set of data about the scale, scope and nature of R&D in its member nations. The OECD was later to seek to better understand the processes of innovation itself and in 1992 it published a common approach to the collection of data on that activity as well, often referred to as the Oslo Manual (see chapter 6 for a discussion of how the Oslo Manual has developed since its initial publication)

Broadly, R&D is any activity that contributes to the sum of human knowledge. Clearly, within this there are a great many activities that contribute to this process and the challenge facing the OECD was to develop an ideal model that would provide an insight into R&D and then to identify the data sources that were widely available. One of the aims of the Frascati Manual was to provide a basis for establishing how much a country spends on its R&D, the Gross Expenditure on Research and Development, also known as GERD. This was achieved by expressing the GERD for any given year as a percentage of overall value of goods and services produced in an economy (GDP) for that year, also sometimes called its R&D intensity.

² For a popular, highly readable account of his work and impact see *The Wizard of Menlo Park: how Thomas Alva Edison invented the modern world* by Randall E. Stross.

The first edition of the Manual was the starting point for what has become a long-term effort to better define R&D activities with the result that Manual has undergone a great many changes and revisions since its initial publication more than sixty years ago. The following sections will examine these changes and explore how they have reflected our changing understanding of what constitutes R&D. The Frascati Manual has been revised many times since its original publication with new editions being published in 1970, 1976, 1987, 1994, 2002 and 2015. The changes to our understanding of the importance of science, research, development and innovation are reflected in these seven editions of the Frascati Manual. This chapter will outline the main approaches that were adopted by original authors in the collection of data on R&D and explore how these have had to be revised over time in response to the changing industrial and policy landscape. In order to provide a sound background for this discussion a greater amount of detail will be provided on the definitions and conceptual approaches contained within the original Frascati Manual, with relatively brief summaries being provided for the main issues contained within the various revisions on the Manual.

The Frascati Manual 1963

At the heart of the Frascati Manual approach was the wish to create a common set of data that would enable a better understanding of the scale, scope and impact of R&D activities at the firm, region, industry and national levels and to provide the basis for comparison and benchmarking. However, in order to define R&D activities it was necessary to define and classify the sectors where R&D takes place and all the resources that are used in that activity like specialist staff and defined capital spending. A key distinction made within this first edition relates to the difference between routine and non-routine work and is made as follows:

‘...the guiding line to distinguish R&D activity from non-research activity is the presence or absence of an element of novelty or innovation. Insofar as the activity follows an established routine pattern it is not R&D. Insofar as it departs from routine and breaks new ground, it qualifies as R&D.’

OECD, 1963: p16

As a result, a great deal of effort went into distinguishing between research and non-research activities such that the creation of prototypes was defined as a form of R&D and the creation of lines for the trial production of the product or system was not. Similarly, the costs of the design work for the prototype may be classed as legitimate R&D expenditure, whilst the costs of the design work for manufacturing may not be classed as R&D expenditure. In this edition of the Manual all R&D undertaken by ‘individual inventors in private households or elsewhere’ (OECD, 1963 p24) is largely ignored due to the challenges in collecting the relevant data. However, the Manual focuses on defining the data to be collected for the following main sectors of the economy as shown below:

Business enterprise

Defined as firms, organisations and institutions which produce goods and services for general sale.

General government

Defined as those governmental organisations that act as the central administration for a community and oversee services that cannot be conveniently and economically provided.

Private non-profit

Defined as private organisations that have not been primarily created with the aim to making a profit from what they do.

Higher education

Defined as universities and other institutes of higher education as well as those establishments that are focused on research like experimental stations and specialist medical research groups.

In order to develop a clear picture of staff involved in an organisation's R&D activity it was also important to collect data on the 'manpower'³ involved. This was divided between qualified scientists and engineers, or their equivalent (broadly those staff possessing a degree, diploma or other relevant training); technicians (broadly those who have received one year or more of non-advanced formal technical education); and other supporting personnel (broadly including skilled artisans and those who manage or administer the activity). This first edition of the Manual also makes the distinction concerning the nature of the activity itself: fundamental research, applied research and development. Fundamental Research is defined as 'Work undertaken primarily for the advancement of scientific knowledge, without a specific practical application in view' (OECD, 1963 p12), with Applied Research being the same thing only with a '...specific practical aim in mind' (ibid). In contrast, Development was defined as 'The use of results fundamental and applied research to the introduction of useful materials, devices, products, systems, and processes, or the Improvement of existing ones' (ibid). According to this first Frascati Manual the actual measurement of R&D is relatively straightforward and involves three apparently simple steps:

- (i) The identification and measurement of the total activity of all specialised research organisations, including those in industry.
- (ii) The subtraction from this total of that proportion of their activity which is defined as "non-research" activity. The exact proportion will depend on the precise definitions and conventions adopted to deal with the various related scientific activities and the non-scientific activities.
- (iii) Adding to this total that R. and D. activity which is not performed in research organisations, but in such other organisations as production units, educational establishments, and so forth
(ibid p14)

However, in order for such an apparently simple process to deliver the useful sectoral and national insights required it was necessary to classify all R&D activity in a number of ways including the nature of the resources employed, the sector in which it took place, the scientific discipline of the research and the nature of the product or service that might have been created. This was highly complex and time consuming and an indication of the many classifications employed is shown in Tables 2 and 3. Despite the great deal of work that went into the creation of the 60 pages of the first Frascati Manual in 1963 it was recognised at the time that it was likely to be flawed and require further improvement and that Frascati was simply a Manual but a process that was:

'... only the first stage of a prolonged effort in this vital, but hitherto neglected field of statistics. Continuous attention will also be needed to improve the concepts and

³ Although this was the term employed in the 1963 edition of the Frascati Manual, it was revised in later editions.

conventions established in this manual and to keep them abreast of new developments in Member countries' (ref, p41)

As had been foreseen by the first Manual's authors there would be a series of revisions over the next several decades to the process of collecting the data required to better understand the scale, scope and depth of R&D within OECD member countries. The main revisions that were made over more than 50 years are summarised in the next section⁴.

Table 2 about here

Table 3 about here

3.3 The Frascati Manual over time

The Frascati Manual has been in existence for over 50 years and its various editions have reflected both the changes in the way in which R&D is conducted and the development of the global economy as a whole. Over its life the Frascati Manual been published in seven editions, with each edition containing a series of revisions to the way in which data concerning R&D should be collected. The following sections provides a summary of the revisions that have taken place, leading on to section 3.4 which will look at the 2015 edition in more detail.

Frascati Manual 1970 – the second edition

It is important to recognise that the Frascati Manual is a negotiated document with OECD members having an important role in determining how it is prepared and what it contains, with the second edition being circulated to member countries around two years before it was finally adopted. Once this process was complete, this first revision focused mainly on making relatively minor changes simply to ensure that the collection of data would conform to the widely used international standards for national accounts and the International Standard Industrial Classification (ISIC) codes which themselves been revised in 1968. The original Manual had been adopted by the 20 founding members and by 1970 the OECD had grown to 22 members, with the accession of Japan and Finland.

Frascati Manual 1976 – the third edition

The second revision of the Frascati Manual was the result of the development of practical experience of what was possible when conducting national surveys on this scale and a great deal of work went into improving the accuracy of the data that was collected. One outcome of this was that the scope of the Manual was expanded to include research in the social sciences and the humanities, with another being a greater focus on the precise classification of the research that took place.

Frascati Manual 1987 – the fourth edition

This edition focused on drafting and layout and no significant changes were made to the key concepts or classifications contained within the Manual. It had also become clear that

⁴ The following sections summarising the main revisions to the Frascati Manual are drawn from Annex 1 of the 2015 Frascati Manual.

although the Higher Education sector played a significant role in R&D, the collection of data within the sector (universities and other tertiary colleges and institutions) was proving to be a challenge and further guidance on this was included in this new edition. This revision also included a supplement aimed at providing practical advice on data collection. By 1987 Australia and New Zealand had joined the OECD, bringing the membership to 24 nations.

Frascati Manual 1994 – the fifth edition

The original Frascati Manual had been written in the early 1960s and it had become clear that the data it required to be collected no longer reflected the changes that had taken place in the industrial landscape and the policy priorities of the OECD member nations. As a result, this edition contained far more detail on issues like internationalisation and transfer sciences, technologies like software, and data on environmental R&D. The integration of R&D data with other economic and industrial time series also took place in order to facilitate improved analysis of overall activity. The Manual also included revisions to the ISIC codes that were to be employed.

Frascati Manual 2002 – the sixth edition

This edition of the Frascati Manual reflected the need to better understand R&D in services, the impact of globalisation on R&D activity, and the issue of human resources for R&D. The revised manual contained new sections on R&D in software together with sections on social sciences, services, globalisation and cooperation in R&D. The revised Manual also contained a greater focus on the human resources engaged in R&D and for the first time made recommendations concerning the collection of data concerning the gender and age of staff engaged in R&D activities. By 2002 the OECD had been joined by the Czech Republic (now called Czechia), Poland, Mexico, Hungary and the Slovak Republic and had grown to 29 members.

3.4 Frascati Manual 2015 – the seventh edition

By the 2015 edition of the Frascati Manual it had grown to 402 pages and was titled ‘Guidelines for Collecting and Reporting on Data on Research and Experimental Development’ and was in its sixth revision of the edition that was originally published over fifty years earlier. It included a series of changes concerning the treatment of R&D tax relief, the collection of data on internal and external R&D personnel, the globalisation of R&D, together with a number of technical changes concerning the collection and classification of the data collected. Despite these changes the core definition of R&D remained, although in a more refined form so that it was more precise, in order to make it consistent with the definition used in earlier editions:

‘Research and experimental development (R&D) comprise creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge.’

OECD 2015: p46

The OECD had also continued to grow far beyond its initial 20 members (by 2015 the OECD had been joined by Japan, Australia, New Zealand, Mexico, the Czech Republic, Poland, Korea, Hungary, Slovakia, Chile, Estonia, Israel and Slovenia, bringing its membership to a

total of 33 nations) and, as a result, the complex interactions of industrial policy priorities and other agendas meant that the creation of a new edition that would satisfy all members and other countries became far more challenging. It is important to recognise that the Manual is a negotiated document and although it had become widely used for a broad range of policy and other uses it always needed to balance the issues of expanding its coverage with maintaining a consistent group of statistics that would enable comparisons over time. However, the expanding membership meant that the Manual also had to be relevant to countries at different stages of development, with different economic structures, different research systems, and varying abilities in the collection, analysis, and use of data. Despite these challenges the clear changes underway in industrial structure and the organisation of R&D meant that it was increasingly important to better understand the impact of research and development activity and new organisational structures created by new actors and the globalisation of value chains. Such new organisational structures often extend beyond the traditional boundaries implied in earlier editions of the Manual, with extramural R&D (that is, external R&D services commissioned by a firm or some other organisation) being considered in some depth in the 2015 revision. By this time the Frascati Manual was now made up of 13 chapters on all aspects of R&D spread over three sections that provide general guidance on defining and measuring R&D, sector-specific guidance on data collection and the measurement of government support for R&D. As would be expected the core definitions around R&D have been refined and developed over successive editions with the precise meaning remaining unchanged:

The definition of R&D

In order for an activity to be classified as Research and Development it must be aimed at uncovering something new (novel); based on original and non-obvious ideas and theories (creative) ; uncertain in its outcome (uncertain); be planned and have its own budget (systematic); and produce results that may be reproducible (transferable and/or reproducible). This can be summarised in the form shown below:

In order for an activity to be classified as Research and Development it must be:

- Novel
- Creative
- Uncertain
- Systematic
- Transferable and/or reproducible

The definitions of the different types of research

R&D covers the three activities of basic and applied research together with experimental development and are defined as ‘Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view. In contrast, Applied research is original investigation undertaken in order to acquire new knowledge’ but is ‘directed primarily towards a specific, practical aim or objective. Experimental development is very different and is defined as ‘...systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes.’ OECD, 2015: p47

The definition of the sectors considered in the 2015 Frascati Manual

Business Enterprise: now more precisely defined as ‘All resident corporations, including not only legally incorporated enterprises, regardless of the residence of their shareholders’ and ‘all other types of quasi-corporations’... The unincorporated branches of non-resident enterprises deemed to be resident and part of this sector because they are engaged in production on the economic territory on a long-term basis.’... ‘All resident non-profit institutions (NPIs) that are market producers of goods or services or serve business.’ (OECD, 2015: p200)

Government: now distinguishing between central (or federal) government, government bodies like agencies, non-profit governmental organisations, regional (or state) government and local (or municipal) government.

Higher Education: now defined as ‘all universities, colleges of technology and other institutions providing formal tertiary education programmes’ together with ‘all research institutes, centres, experimental stations and clinics that have their R&D activities under the direct control of, or administered by, tertiary education institutions.’ (OECD, 2015, p260)

Private non-profit: defined as non-profit institutions serving households apart from those classified as part of the Higher education sector together with households and private individuals engaged or not engaged in market activities.

Rest of the world: this is a catch-all category that intends to capture the scale and scope of the globalisation of R&D.

The 2015 edition of the Frascati Manual contains a series of revisions and clarifications that are intended to reflect the changing nature of knowledge, R&D and developments in the world economy.

3.5 R&D data in a changing world

The OECD’s various editions of the Frascati Manual have been focused on providing clarity on what counts as legitimate and measurable R&D activity and provides guidance on what data must be collected in order to provide a consistent picture that is comparable over time across sectors, industries, economies and nations. It is a statistical activity that is intended to provide detailed insights into what has been recognised as a highly important activity within developed economies. As such it is primarily a measuring process that provides a retrospective view of the level of R&D expenditure of the firm or other unit, but which can be aggregated to provide valuable insights at the level of the firm, sector, industry or the whole economy. However, it is inherent in the very nature of data collection activities of this sort that the analysis they provide can only be based on the data they collect, and if that data relates to activity in the past, then the analysis they provide is similarly dated. Similarly, if the data that is collected no longer accurately reflects the entirety of the way in which R&D is conducted within firms, then the analysis produced will only provide partial insights on the levels of activity as a whole. In other words, despite the great efforts to provide a detailed set of guidelines that can provide a consistent set of data the analysis that results produced can only ever be an *indicator* of the level R&D activity and, as such, should be treated with

caution⁵. However, given that the Frascati Manual provides guidance on the collection of data concerning R&D activity within a shifting political, economic and industrial context it is to be expected that it would be the subject of repeated revisions. Indeed, this was explicitly recognised in the conclusions of the original Frascati Manual:

‘The measurement of R. and D. is still in its early stages. Its level has been compared to that of national income statistics before the second World War. It is quite evident that there are still important conceptual and practical problems to be resolved, and that margins of error for some estimates are still too large for satisfaction. Nevertheless, even with their present imperfections, these statistics have already proved their worth as useful tools for analysis and policy formulation. All forms of measurement involve successive approximations and constant improvement and refinement of concepts and methods. This process will continue in the case of R. and D. statistics too. It is quite evident that there are still important conceptual and practical problems to be resolved, and that margins of error for some estimates are still too large for satisfaction. Nevertheless, even with their present imperfections, these statistics have already proved their worth as useful tools for analysis and policy formulation. All forms of measurement involve successive approximations and constant improvement and refinement of concepts and methods. This process will continue in the case of R. and D. statistics too.’
OECD 1963: p40)

Arguably, the many revisions to the Frascati Manual have been both concerned with reflecting the changes in the conduct of R&D and refining the ways in which data is collected and analysed. The sheer growth in the size of the Manual from 60 to 402 pages long is as reflective of the need for an increase in the clarity and precision of its definitions and methodological approaches as it is of the need to deal with changes in the nature and geographical dispersion of R&D and those who are engaged in its various activities. Issues like accounting for the nature and location of R&D within multinationals, the globalisation of the R&D process and the age and gender of those involved were not the main focus of efforts from the beginning. Similarly, it was only in the third edition that research in the Social Sciences and Humanities were included. There are clear themes in the six revisions that have taken place in the Manual, with these revisions reflecting the changes that have taken place in the economies of the member nations. These themes can be summarised as follows:

Changes in where R&D takes place

In early editions of the Manual there was an implicit assumption that R&D was an activity that took place largely within the borders of nations. Data on the movement of R&D-related funds to and from ‘Abroad’ were collected but it was not until the publication of the 2015 edition of the Manual that there was an explicit recognition of the international integration of many of the components of a modern R&D system whose scope was widened to include finance, production and specialist R&D services. In the 2015 edition the globalisation of R&D was given its own chapter with far greater consideration being given to private multinational enterprises and the emergence of the cross-border trade in specialist services relating to R&D. The 2015 revision of the Manual provided guidance concerning the collection of data on three distinct aspects of the globalisation of R&D:

⁵ Further, as discussed above, the analysis provided will always be retrospective in nature and as a result is sometimes referred to as a *lagging indicator*.

Funding for R&D that crosses national boundaries;
R&D costs and staffing within multinational organisations;
The trade in R&D services internationally.
OECD 2015: p301

However, it is clear that the globalisation of R&D presents a formidable challenge to the collection of data as it may now be a part of a complex global value chain that involves a wide array of suppliers and be present in a dispersed production process that produces both goods and services. Further, the process of R&D may itself be dispersed between a range of different organisations located in different countries around the world.

R&D and the growth of services

When the first edition of the Frascati Manual was published in the early 1960s manufacturing still accounted for a major part of the GDP of most developed economies, with services being simply one part of a broad mix of activities. This has now changed and services are now the source of the overwhelming majority of GDP in most developed economies⁶. The measurement of R&D in services (e.g. banking, insurance, healthcare etc) is considered in greater detail in the 2015 revision of the Manual, with services being defined as ‘...the result of a production activity that changes the conditions of the consuming units, or facilitates the exchange of products or financial assets’ (OECD, 2015: p70) However, the Manual also recognises that identifying R&D activities in the context of services may be more difficult as research and development may not be a separate activity and may simply be viewed as part of service delivery. As a result, R&D in this context will not tend to have a dedicated department or budget as is often the case in manufacturing. However, much like globalised R&D, the collection of data concerning R&D in services is also challenging as it may be difficult to allocate a defined group of activities to a particular service and it can be hard to disentangle research or development activities from other associated innovation processes (ibid).

R&D and the increasing importance of software

In the 1960s software was a minor concern for most organisations, yet today it is ubiquitous and plays a vitally important role in many R&D projects. However, once again, software is unlike manufacturing as it can often be hard to identify research and development features within a software development process. The 2015 Frascati Manual recognises this and clearly rules out all routine software-related activities (OECD 2015: p65) focusing instead on the collection of data concerning activities that would be considered an advance in the area, including:

- the development of new operating systems or languages;
- the design and implementation of new search engines based on original technologies;
- the effort to resolve conflicts within hardware or software based on the process of re-engineering a system or a network;
- the creation of new or more efficient algorithms based on new techniques;
- the creation of new and original encryption or security techniques.’

OECD, 2015: p66

⁶ For example, the Office for National Statistics reported that by 2016 services accounted for 80% of the UK economy, having grown from 56% in 1970 (ONS, 2023)

These three ‘new’ elements of globalisation, services and software are all a long way from the traditional world of manufacturing, with its specialist R&D departments and clearly identified, product-focused, innovation pathways. At the same time, changes in communication technology, organisational structure and Higher Education has meant that the geographical spread of those able to engage in various aspects of the R&D process has grown dramatically. As a result, it can be argued that the changes to the Frascati Manual have simply been a series of ‘fixes’ that maintain an aging data collection system that is struggling to reflect modern technologies and industrial structures.

R&D and the growth in new scientific fields

There is a great deal of knowledge still to be uncovered, and the growth in the number of separate and distinct fields of scientific knowledge between the 1963 edition of the Frascati Manual and the 2015 version is stark. As can be seen from a cursory examination of Table 4 covering the 50 or so years of the Manual's existence entirely new fields of science have emerged and become prominent enough to be identified and for data to be collected concerning the level of R&D activity. Over this same period, as the data collection has become more systematic and experience in data collection has grown, the relevant scientific fields on which data is collected have also become more refined and streamlined. This process of refining is likely the result of the increasing complexity of the knowledge that is generated. Arguably, the breadth and nature of the knowledge that is being generated today is more complex and subtle than that of the 1960s, with clear implications for the Frascati Manual.

Table 4 around here

3.6 Conclusions

The world of the 1960s was very different to the world we inhabit today and the policy preoccupations of the world at that time, reflected in the Frascati Manual, are also very different. The 1960s were a period in which the Beatles were in the charts, manufacturing was dominant in most developed economies, the production of services formed a small part of overall activity, and industrial R&D largely took place in laboratories. Mobile telephones only appeared in comic books, computers were not in widespread use in business and the invention of the Internet was 20 years in the future. Globalisation, Artificial Intelligence (AI) and Big Data did not exist, the circular economy and sustainability were not on the policy agenda, and global heating was not an environmental or political concern. This was also a world that was still recovering from a major war (WWII), was divided between East and West with the Soviet Union appearing to be a major technological force, and Japan, South Korea and China yet to be the manufacturing and research powerhouses they would later become. At this time the Frascati Manual was called ‘The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Development’ and was 60 pages in length. It was the first attempt to create a set of definitions that would guide the collection of a common set of data relating to R&D internationally. As a result, a great deal of this very first edition was taken up with being clear which activities did, and did not, relate to R&D and could therefore be counted.

At the same time the Frascati Manual was largely a reflection of the preoccupations of the developed Western world, a world that was based on the production of finished goods, the use of fossil fuels, preoccupied with growth and individual consumption and insecure in its position facing the ideological opponents that made up the Eastern Bloc. The creation of new

knowledge in this context was of paramount importance and the collection of data concerning the broader activities of R&D within an economy was a vital activity. The many revisions to the original Frascati Manual of 1963 may be seen as responses to the huge changes that took place both in Western developed economies and in the way that R&D began to take place in a range of different countries around the world. The overwhelming shift towards the production of services in the countries of the OECD, the central role of software both in products and services, the globalised nature of R&D activities, and the growth in the number of countries involved meant that data became increasingly hard to collect and the data that was collected became less reliable. Indeed, it was only in the sixth edition of the Manual that specific annexes were included that provided guidance on the collection of R&D data on ICT (information and communication technology), health and biotechnology. Arguably, the approach and the world view that was embodied in the original Frascati Manual has reached its limit and has to fundamentally change. The undeniable fact and implications of global heating also raise important questions for the ongoing sustainability of the entire economic model represented by the Frascati approach. However, it is important to recognise that the Frascati Manual is the result of the cooperative efforts of OECD members and it is unlikely that there will be any radical changes in its approach until those members initiate such changes – it is simply a reflection of current approaches within the OECD membership. In time the many challenges faced by OECD members as the world changes, and the revisions in the approach to R&D that will be required, will be reflected in the Frascati Manual. Until that time it is important to view the Manual as a document that reflects the approaches and practices of a distinct era in human civilisation.

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Table 1: OECD members with year of accession (source OECD)

1961	Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States
1962	Italy
1964	Japan
1969	Finland
1971	Australia
1973	New Zealand
1994	Mexico
1995	Czech Republic
1996	Hungary, Korea, Poland
2000	Slovak Republic
2010	Chile Estonia Israel Slovenia
2016	Latvia
2018	Lithuania
2020	Columbia
2021	Costa Rica

Table 2: Examples of Standard Industrial Classifications (SIC) employed within the Frascati Manual

Manufacturing

- Food and drink
- Tobacco
- Textiles
- Clothing and footwear, leather
- Wood, cork and furniture
- Paper Printing and publishing
- Petroleum refining and extraction
- Drugs
- Chemicals
- Rubber products
- Stone, clay and glass
- Ferrous metals
- Non-ferrous metals
- Fabricated metals products
- Machinery, excluding electrical
- Instruments
- Other electrical machinery and apparatus
- Aircraft and missiles
- Motor vehicles and parts
- Shipbuilding
- Other transport equipment
- Other manufacturing

Table 3: examples of the classification of Scientific fields from the original (1963) Frascati Manual

Principal fields	Sub-division of principal fields
A. Natural Sciences	<ol style="list-style-type: none"> 1. Mathematics 2. Physics, mechanics, electronics, astronomy 3. Chemistry, physical chemistry 4. Biology, botany, zoology, bio-chemistry, bio-physics 5. Geology and earth sciences, meteorology, geophysics 6. Other
B. Engineering	<ol style="list-style-type: none"> 1. Metallurgy, mining 2. Mechanical 3. Construction, civil 4. Electrical 5. Aeronautical 6. Chemical, fuel and petroleum technology 7. Textile 8. Geodesy 9. General technology- and applied science 10. Other
C. Medical Sciences	<ol style="list-style-type: none"> 1. Medicine 2. Dentistry 3. Pharmacy 4. Other
D. Agriculture	<ol style="list-style-type: none"> 1. Agronomy, rural science 2. Forestry, horticulture 3. Dairying, animal husbandry 4. Veterinary science 5. Other
E. Social Sciences	<ol style="list-style-type: none"> 1. Political science, diplomacy 2. Economics, commerce, banking 3. Sociology, ethnology 4. Other
F. Humanities and Fine	<ol style="list-style-type: none"> 1. Humanities Arts 2. Fine Arts 3. Education 4. Other

Table 4: examples of the classification of Scientific fields from the 2015 Frascati Manual

1. Natural sciences	1.1 Mathematics 1.2 Computer and information sciences 1.3 Physical sciences 1.4 Chemical sciences 1.5 Earth and related environmental sciences 1.6 Biological sciences 1.7 Other natural sciences
2. Engineering and technology	2.1 Civil engineering 2.2 Electrical engineering, electronic engineering, information engineering 2.3 Mechanical engineering 2.4 Chemical engineering 2.5 Materials engineering 2.6 Medical engineering 2.7 Environmental engineering 2.8 Environmental biotechnology 2.9 Industrial biotechnology 2.10 Nano-technology 2.11 Other engineering and technologies
3. Medical and health sciences	3.1 Basic medicine 3.2 Clinical medicine 3.3 Health sciences 3.4 Medical biotechnology 3.5 Other medical science
4. Agricultural and veterinary sciences	4.1 Agriculture, forestry, and fisheries 4.2 Animal and dairy science 4.3 Veterinary science 4.4 Agricultural biotechnology 4.5 Other agricultural sciences
5. Social sciences	5.1 Psychology and cognitive sciences 5.2 Economics and business 5.3 Education 5.4 Sociology 5.5 Law 5.6 Political science 5.7 Social and economic geography 5.8 Media and communications 5.9 Other social sciences

6. Humanities and the arts

6.1 History and archaeology

6.2 Languages and literature

6.3 Philosophy, ethics and religion

6.4 Arts (arts, history of arts, performing arts, music)

6.5 Other humanities