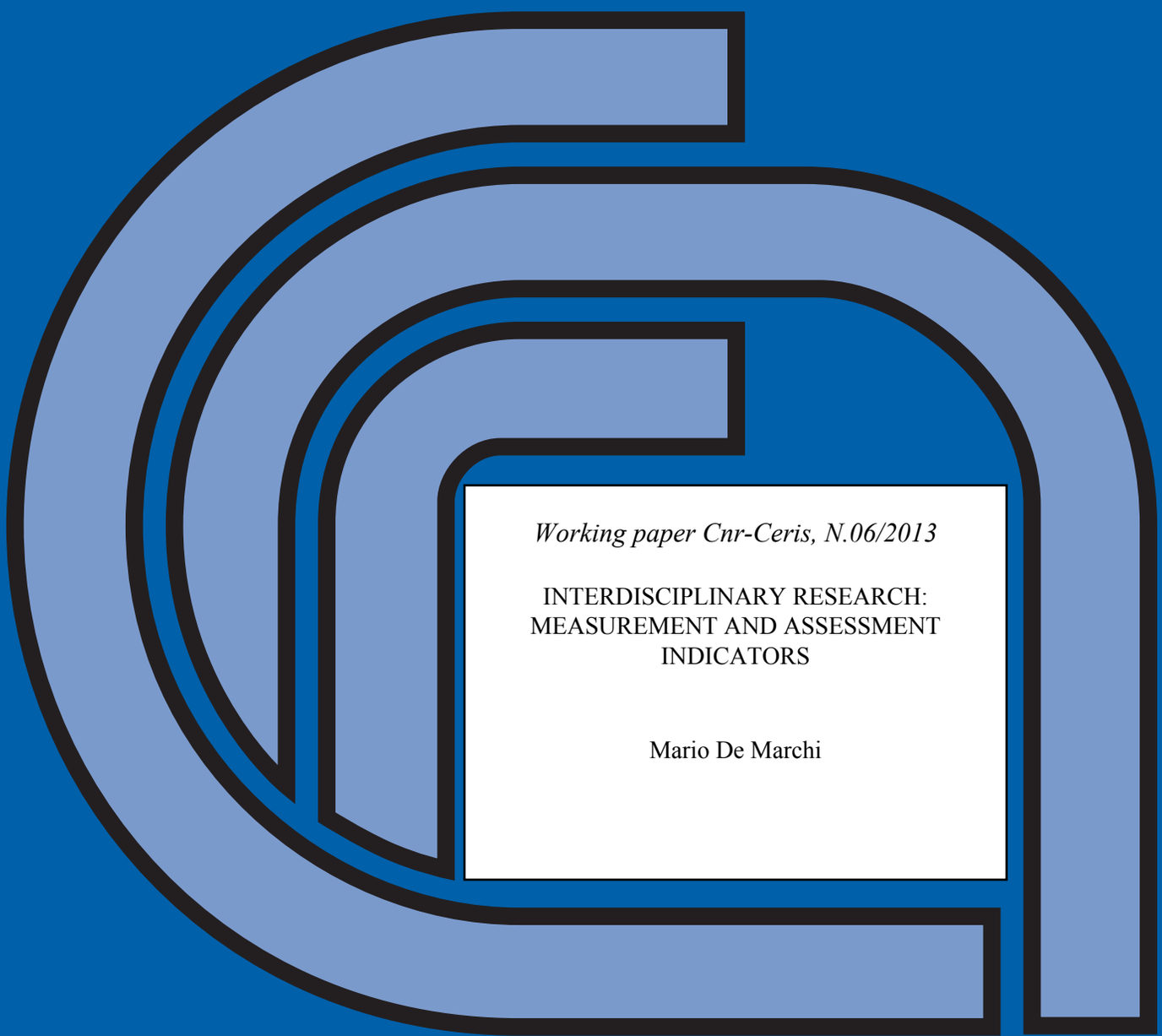
Consiglio Nazionale delle Ricerche

CERIS
ISTITUTO DI RICERCA
SULL'IMPRESA E LO SVILUPPO

ISSN (print): 1591-0709
ISSN (on line): 2036-8216



Working paper Cnr-Ceris, N.06/2013

INTERDISCIPLINARY RESEARCH: MEASUREMENT AND ASSESSMENT INDICATORS

Mario De Marchi

Working Paper

CERIS ISTITUTO DI RICERCA SULL'IMPRESA E LO SVILUPPO

WORKING PAPER CNR - CERIS

RIVISTA SOGGETTA A REFERAGGIO INTERNO ED ESTERNO

ANNO 15, N° 6 – 2013
Autorizzazione del Tribunale di Torino
N. 2681 del 28 marzo 1977

ISSN (print): 1591-0709
ISSN (on line): 2036-8216

DIRETTORE RESPONSABILE

Secondo Rolfo

DIREZIONE E REDAZIONE
Cnr-Ceris
Via Real Collegio, 30
10024 Moncalieri (Torino), Italy
Tel. +39 011 6824.911
Fax +39 011 6824.966
segreteria@ceris.cnr.it
www.ceris.cnr.it

SEDE DI ROMA
Via dei Taurini, 19
00185 Roma, Italy
Tel. +39 06 49937810
Fax +39 06 49937884

SEDE DI MILANO
Via Bassini, 15
20121 Milano, Italy
tel. +39 02 23699501
Fax +39 02 23699530

SEGRETERIA DI REDAZIONE
Enrico Viarisio
e.viarisio@ceris.cnr.it

DISTRIBUZIONE
On line:
www.ceris.cnr.it/index.php?option=com_content&task=section&id=4&Itemid=64

FOTOCOMPOSIZIONE E IMPAGINAZIONE
In proprio

Finito di stampare nel mese di Aprile 2013

Interdisciplinary research: measurement and assessment indicators

Mario De Marchi

National Research Council of Italy
CNR-CERIS
Institute for Economic Research on Firm and Growth

Via dei Taurini 19, Roma

Tel.: +39 06-4993 7848;
fax : +39 06 4993 7808;

email: m.demarchi@ceris.cnr.it

ABSTRACT: In order to implement appropriate policies to face the difficulties and remove the obstacles that hinder interdisciplinary research, it is necessary to clarify how this ever broader and more dynamic portion of science works and which incentives best support the activities of scientists. Interdisciplinary studies are a peculiar aspect of the activities performed by researchers operating at the frontier of science, for instance in cutting-edge sectors. They might encompass fields of investigation that already exist, but they cannot be exclusively ascribed to any one of them. Abstract answers regarding the very unusual matters investigated by interdisciplinary research would make it extremely difficult to provide quantitative output measurements and evaluations. Yet, the shift from general abstract answers to specific empirical problems, which is the objective of most interdisciplinary research, turns out to be an advantage when assessing this type of research. Concentrating on problems and on approaching their solutions in objective quantitative terms can allow for output measurement and assessment also in the case of interdisciplinary research. This can be achieved by using precision and efficiency parameters able to provide public policies and entrepreneurial activities with content that is as clearly defined and as rigorous as that of specialist research.

KEYWORDS**:** Scientific research; Research evaluation; Research policy.

JEL CODES: O30

SUMMARY

1. SUMMING UP CONCEPTIONS OF INTERDISCIPLINARY RESEARCH

1.1 Introduction

Interdisciplinary studies are an ancient phenomenon which is becoming increasingly important in the field of science. The definition of interdisciplinary studies is partially controversial, but some of their features can be identified right away. Interdisciplinary research activities comprise studies carried out using new methods and concerning new kinds of problems; due to their peculiar nature, these studies do not clearly fit into the research programmes currently followed within the specific disciplines into which knowledge is usually structured (Huutoniemi, Thompson Klein et Al., 2010). Dividing knowledge and the search for knowledge into sectors, such as physics and chemistry and their subsectors, is a fairly recent innovation. In the long history of scientific thought and investigation, the division commonly adopted until two hundred years ago mainly concerned the nature of knowledge, which could be either true (episteme) or a belief (doxa) and was defined depending on the method through which it was achieved (contemplation and observation) rather than used for practical purposes (techne) (Weingart and Stehr, 2000).

Interdisciplinary research is strongly driven by the growing complexity of scientific and technological systems, by the ever changing needs of society, and by the problems these pose to science. As a consequence, interdisciplinary research is rapidly becoming an essential component of research in general. However, it also faces a number of obstacles hindering its development. These arise, among other causes, from the consolidated structure of the scientific system and from the tendency towards greater specialisation, which has characterised science in the last few centuries and has led to the segmentation of knowledge and of the academic bodies in charge of researching and circulating it.

In order to deal with the difficulties and remove the obstacles that hinder the development of interdisciplinary research, suitable public policies must be formulated and implemented and, to do so, it is necessary to clarify how this ever broader and more dynamic portion of science works. In particular, it is important to analyse the incentives that govern the activities of scholars and influence their decision to perform interdisciplinary research, as well as the ways in which they carry out this type of research.

The first step in the creation of suitable policies obviously consists in measuring interdisciplinary research. Its quantitative measurement can firstly help in analysing and understanding the phenomenon; then, it can be used to assess interdisciplinary research, which is an essential tool in public policies for science, aimed at promoting the effectiveness and efficiency of academic and scientific systems financed by the taxpayers' money. Our paper focuses precisely on this topic, and its first part aims to investigate in detail the matter of the dimensions along which interdisciplinary research develops.

Interdisciplinary studies are often a peculiar aspect of the activities performed by researchers operating at the frontier of science. Cutting-edge researches which currently seem to fit into the category of interdisciplinary studies are being carried out in the fields of mathematics and physics (for instance, string theory), as well as chemistry

and biology (for instance, studies about lab synthesis of new forms of life). Yet, there are other examples, either from the fairly recent past (Crease, 2008) or from older periods, such as the studies on radiations – which developed throughout the nineteenth and twentieth centuries and brought together, among others, physics, chemistry, medicine, and engineering – or the researches carried out in the field of cybernetics – which have combined, for instance, the science of control systems, electronics, game theory, neuroscience, and psychology, though the list is far from complete. This undoubtedly shows that interdisciplinary research activities encompass fields of investigation that already exist, but they cannot be exclusively ascribed to any one of them.

Another aspect which immediately stands out when the nature of interdisciplinary studies is investigated is the quintessentially dynamic quality of the scope and development of the problems addressed by the search for new knowledge in the interdisciplinary field (Klein, 2010). Conversely, research carried out in predefined fields tends to keep within its often rather strict and well-established boundaries, determined by conventions and by the organisation of academic disciplinary sectors.

Hence, as time goes by and scientific activities develop further, the interdisciplinary lines of investigation being pursued at any given moment might die out. Such a situation occurs when the topics being addressed within an interdisciplinary research sector cease to raise interest, which seems to have happened, to a certain extent, with the concepts of mathematical catastrophe theory applied to natural sciences. Indeed, scholars placed high hopes in the heuristic value of said theory during the 1980s, but it has lately been put aside. On the contrary, in the luckiest cases, interest in interdisciplinary investigation can trigger the creation of entirely new scientific research sectors, which seems to be happening, for instance, with the application of quantum physics to the designing of innovative supercomputers. Nevertheless, the situation is constantly evolving and no easy generalisations should be drawn, since the existence of an interdisciplinary sector at present does not necessarily mean that it will turn into a new discipline at some point in the future (Klein, 2010, p. 22).

1.2 Some possible meanings of the concept of interdisciplinary research.

Investigating interdisciplinary research appears to be a complex task right from the outset, from the very first steps to be taken by providing a definition of it. Said definition would be necessary to qualify its field of investigation and to clarify the nature of the matters it addresses. Nevertheless, it is extremely difficult to attain a concept of interdisciplinary research accepted by all scholars or at least by most of them, due to the countless facets this issue implies depending on the points of view and parameters adopted to define it. Because of the complex nature of the question, several taxonomies of interdisciplinary research have been proposed. They consider a large number of causal factors that influence the development of classifications, such as critique, complexity, or the importance of problem solving in determining what drives research activities (Klein 2010). It is now a well-established tradition to follow the key contribution by the OECD (Apostel et Al.) which suggests distinguishing among interdisciplinarity,

multidisciplinarity and transdisciplinarity.

In multidisciplinarity, the various disciplines contributing to research activities remain separate and the existing structure of knowledge is not called into question. However, the disciplines involved interact deeply and the evolution of one of them influences the evolution of the others, as seen, for instance, in the developments of philosophy and their effects on the importance of empirical measurement in natural sciences during the eighteenth century (Kuhn, 1977, p. 223).

In interdisciplinarity, in the strict sense, the barriers between disciplines are overcome for various reasons and in various circumstances. A scholar's interdisciplinary research activities might encompass one or more already existing scientific disciplines, but this is not what makes them interdisciplinary. Research is interdisciplinary when it also comprises methods, problems, and information that are already included in those disciplines, but it does not simply cover and elaborate on topics that are currently being dealt with by science normally organised in disciplinary fields. Further disciplines are included to solve complex problems or to try and achieve a shared goal; disciplines having compatible methods and paradigms merge or borrow certain methods from one another; theoretical models are exchanged and new syntheses are produced by the hybridisation of models belonging to different disciplines. Therefore, interdisciplinary research is distinguished from multidisciplinary research, which encompasses several pre-existing branches of science, because the former strives to provide synthesis and innovation, a feature that is not present in the latter, where various disciplines are simply placed side by side. This difference between interdisciplinarity and multidisciplinarity can be clarified through an example. Applying the principles of physics, which allow a sphygmomanometer to work, and those of medicine, which provide a diagnosis based on blood pressure measurement, is an example of multidisciplinarity (medical physics). The exploration of a new problem – such as conveying active ingredients to specific cells within the human body by overcoming the body's protection barriers to stop this intrusion from the outside through the use of nanotechnologies based on physics principles not applied until now – represents instead an example of interdisciplinarity (biophysics).

In transdisciplinarity, a common system of axioms encompasses several disciplines, it can promote integration of knowledge and go beyond the limited goals of each discipline, in order to try and provide solutions to problems investigated by more than one sector. Hence, interdisciplinary research is different from transdisciplinary research because it does not simply encompass different sectors and the issues and topics they address. Indeed, interdisciplinary research is not merely an axiomatic synthesis of the methods and questions already used in science – as is the case, instead, with transdisciplinary research – , but it deals with a whole new set of matters.

1.3 An operational definition of interdisciplinary research.

As the various issues concerning the classification of these concepts are investigated further, new definitions are provided and, consequently, it becomes possible to use a growing number of criteria to measure the corresponding phenomena. We do not aim to explore this matter in great

detail, as it more closely concerns those who specialise in taxonomies of interdisciplinary research and also because such an analysis might prove extremely long and complex. On the contrary, our purpose is to provide an operational definition of interdisciplinary research, able to allow for a straightforward discussion on the criteria used to elaborate indicators for the empirical measurement and assessment of the phenomenon in order to devise effective public policies.

This is why we have decided to disregard any possible methodological complications, putting off their analysis until further investigations, and we move on to formulate a provisional yet operational definition of interdisciplinary research. This is a definition from without, which means that it focuses on identifying what interdisciplinary research is *not*, rather than one of the traditional definitions from within, i.e. those definitions which explain what is included in the concept of interdisciplinary research. The method of defining from without seems preferable in this case because a definition from within of the content of interdisciplinary research might generate a regression ad infinitum: the terms defining the content should, for the sake of completeness, be in turn defined by other terms, and so on (Popper, 1983).

Therefore, in what follows, we shall use our definition from without, despite being aware of its limitations. We shall do so exclusively in relation to the measurement of interdisciplinary research, with the specific purpose of identifying a precise and narrow subject for our discussion. Obviously, this does not imply denying the importance of the researches and in-depth investigations carried out by those specialising in taxonomies of interdisciplinary research, which have served as the basis for our study and the results of which shall be used to discuss the concepts presented in the remainder of this paper.

To begin with, we could define interdisciplinary research from without for what concerns its methods and theoretical-empirical procedures as scientific activity in which information, data, tools, perspectives, concepts, and theories (National Academy of Sciences et Al., 2005) *do not* come exclusively from one discipline or specialised body of knowledge. Moreover, as for defining interdisciplinary research from without for what concerns the issues it addresses, it can be argued that interdisciplinary studies have the purpose of increasing fundamental knowledge or of solving problems whose solutions *do not* lie exclusively within a *single*, already existing discipline.

Thanks to their broadness, these definitions might be satisfactory for the time being in order to proceed with our analysis. Nevertheless, for the concept of interdisciplinary research thus defined to be suitable and sufficient for the subject of our investigation, it is necessary to further specify it. Analysing the meaning of the terms used in the definition of interdisciplinary research and their theoretical implications is essential and unavoidable if we are to take the discussion to a more general level and prevent it from remaining limited in scope and poor in content. Said analysis can focus on the dimensions along which interdisciplinary research operates, so that the concept can be clarified on the basis of the specifications taken on by the phenomenon in the scientific and academic reality, i.e. whether research is carried out by one or more scholars or whether it is theoretical or experimental. In the following pages, we shall analyse some of

these aspects separately, beginning with some possible classifications of interdisciplinary research developed from different points of view on the matter, which place emphasis on certain dimensions of the concept of interdisciplinarity and of related concepts. In general, it seems possible to identify several features of interdisciplinary research, distinguishing among various aspects such as, for instance, who performs interdisciplinary research, what problems it addresses, which methodologies are adopted, which is the relative importance of theory versus experimentation, and which instrumentation is used. This brief list is by no means exhaustive but it might be sufficient for the purposes of this study, which, as mentioned above, mainly deals with the quantitative measurement of interdisciplinary research and the most appropriate policies for its promotion.

2. LOOKING FOR INDICATORS TO MEASURE AND ASSESS INTERDISCIPLINARY RESEARCH.

2.1 Interdisciplinary research analysed along various dimensions.

First of all, like all types of research, interdisciplinary research is carried out by the minds of scholars. From a sociology of science point of view, a distinctive aspect of interdisciplinary research is that the expertise it requires can sometimes be found within the mind of a single person; in such cases, an individual scholar masters several disciplinary fields and combines them. Conversely, in other situations, a plurality of individuals, each with specific expertise in their respective disciplinary fields, collaborate and share views on a specific problem; in such cases, the work is carried out by research groups (Pfirman et Al., 2005). The mix and the novelty of perspectives characterising interdisciplinary research might manifest themselves more evidently and immediately when this type of research is performed by a single individual, since providing a comprehensive overview of new problems by using new methods is a logical consequence of the unity of the thinking subject. Hence, it might be appropriate to distinguish interdisciplinary research carried out by a plurality of scholars, working in team but retaining their individual specialisations and pursuing careers in separate academic fields, from interdisciplinary studies performed by individual scholars, who build their entire careers in the field of interdisciplinarity.

Secondly, interdisciplinary research is like all other scientific activities in that it unfurls at both the theoretical and the experimental level. From a methodological point of view and for what concerns the measurement of interdisciplinary research, this distinction is of the greatest relevance. Reality is studied empirically by using experimental devices, but their designing and the way in which they work often derive from the complex application of ideas coming from a plethora of different disciplines (National Academy of Sciences et Al., 2005). On the other hand, speculation bound within the more or less crystallised research programmes of traditional scientific disciplines is better suited to theoretical research.

Therefore, we can reasonably expect the frequency of interdisciplinary research activities to be higher in the field of experimental research. Conversely, theoretical reflections on limited problems are easier when the issues addressed by scholars are clearly formulated within a well-established branch of knowledge.

2.2 A source of interdisciplinary research: new scientific problems and problems external to traditional disciplines.

A useful approach to analyse the characteristics of interdisciplinary research focuses on the nature of the matters it tries to address. Interdisciplinary research typically deals with new problems, which, as such, do not necessarily fall into any pre-existing discipline; these are called exodisciplinary problems (Popper, 1963). Said new exodisciplinary problems are sometimes formulated by scientists based on their sheer intellectual curiosity, but they can also originate from outside the scientific community. This happens very often when scientific research has to find answers to questions arising from the needs of the state (which are frequently military needs), of the industrial sector, or of society in general. An example of this is the issue addressed by the Manhattan Project. The growing drive created by the needs of the state, of the industry, and of society leads to the ever higher occurrence of interdisciplinary research. This phenomenon tends to counterbalance, at least partially, the tendency towards a more and more fragmented disciplinary organisation of science and is opposed to the tendency towards specialisation in scientific work, which has characterised the last few decades. By its very nature, interdisciplinary research concerns new and complex problems, which can be solved thanks to the efforts of experts in natural science as well as technologists, scholars specialising in social science as well as researchers in the field of humanities. Situations of this kind often arise when the protection and enhancement of cultural heritage is concerned, as this matter involves scholars from several disciplines: scientists and technologists in relation to restoration and preservation techniques; economists in relation to the promotion of cultural assets, the calculation of their value and of the costs society must bear to protect them; and experts in humanities in relation to the artistic and social content of cultural heritage.

3. INDICATORS FOR THE QUANTITATIVE MEASUREMENT OF INTERDISCIPLINARY RESEARCH.

3.1 Similarities to measurement issues in disciplinary research.

A procedure to measure and assess interdisciplinary research suited to acting as the basis for rational policies should obviously include quantitative methodologies, which are, by nature, more objective and allow policy makers to evaluate with greater transparency the effectiveness and efficiency of measures that have already been adopted or are about to be implemented. Many of the procedures and principles used in the measurement and quantitative assessment of interdisciplinary research are similar to the methodologies usually followed within the field of mono-disciplinary research (Klein J.T., 2008). Therefore, also in the case of interdisciplinary research, it is possible to use input and output indicators that are common in the measurement of research in general (Anzai et Al., 2012). For instance, the results of interdisciplinary research can be measured by counting the number of publications (and citations generated) arising from research activities concerning interdisciplinary issues performed either by a single scholar or by a group of scientists. It is also possible to

measure the value of the resources invested in interdisciplinary research activities, as is generally done in science, by calculating the time used by researchers or the amount of financing allocated to various projects. In principle, the above would present no major difficulty if the concept of input and output indicators were considered exclusively from an abstract point of view, but careful specifications are needed when we move on to consider the way in which these indicators are devised and measured in practice.

In the following paragraphs we shall deal with these issues, arguing that the concept of interdisciplinary research implies even bigger problems than those arising from research in general. This obviously translates into greater difficulties when trying to assess and measure interdisciplinary research. Nevertheless, it is possible to provide operational definitions of the variables involved in these procedures, which helps in devising acceptable methodologies for the analysis of this field.

3.2 Specificity of interdisciplinary research.

Compared to science in general, interdisciplinary research displays numerous idiosyncratic features that come into play when one tries to identify specific indicators able to measure and assess research from a quantitative point of view. Here follows a brief description of some of these features.

3.2.1 Output indicators: peer reviewing in interdisciplinary research.

As with disciplinary research, it is obviously possible to measure the output of interdisciplinary research and assess it from a quantitative point of view by counting publications and citations. However, in doing so it is necessary to proceed with great caution, focusing on the specific procedures linked to defining and counting publications. According to the standard procedures of contemporary science, the decision to define the contribution of an individual scholar or of a group of scholars as a publication originates from the assessment of said contribution provided by peer scientists, i.e. the process of peer reviewing (Spier, 2002). As far as disciplinary research is concerned, the identification of peer scientists does not usually present any great difficulty. Peer reviewers are normally chosen from among scholars who enjoy enough prestige within the academic community investigating the matter dealt with in the contribution to be assessed (Lamont, 2009). On the contrary, in the case of interdisciplinary research, it is often much harder to identify with precision the reference academic community which a scholar or a contribution are linked to. Hence, it might prove extremely problematic to find suitable peers, truly capable of analysing and evaluating the content of articles submitted to journals by interdisciplinary scholars. Furthermore, the strictly disciplinary nature of the vast majority of scientific journals makes it harder for interdisciplinary scientists to submit their contributions to them. This situation leads to a negative bias in the classification of publications, although of equal value, against the contribution offered by interdisciplinary scholars to the progress of science, a factor which must be taken into account when assessing the contribution of these scholars in quantitative terms.

3.2.2 Input, resources invested in interdisciplinary research.

Another set of indicators for the measurement of interdisciplinary research and of the policies related to it concerns their financial and human input. In the vast majority of cases, the funds and personnel allocated to interdisciplinary scientific activities by universities and research organisations are not classified and recorded separately but are simply included in the resources allocated to individual disciplines (National Academy of Science set Al., 2005). This leads to a negative bias in the measurement of interdisciplinary research efforts, which must be taken into account when evaluating the role played by these studies as well as their weight within the public scientific system. Nevertheless, it must be underlined that said bias is a lot less evident when one considers the financial and human input of studies promoted by subjects external to the academia, for example in the case of researches for military purposes or projects commissioned by the industrial sector.

3.2.3 Research ownership and apportionment of scientific products among scholars.

When interdisciplinary research is considered, it becomes rather difficult to correctly apportion the scientific output of research activity among the scholars participating in a given project. This matter is somehow less complicated in the case of multidisciplinary projects involving participation by scientists operating in clearly defined sectors, since the measurement and assessment of their joint output can be carried out by clearly ascribing each of their products to the various disciplines in which they operate. Conversely, when research ownership belongs to a group of scholars who operate in interdisciplinary sectors – where, although the value of the ideas produced is the same, publication is harder to achieve –, the accurate apportionment of contributions to individual scientists is complex due to the lack of precise references, which are available instead in the case of publications clearly ascribable to mono-disciplinary sectors (Feller, 2006). Therefore, measuring and assessing the production of scientists operating in interdisciplinary fields and working in research teams proves a rather challenging task.

3.2.4 Theoretical and experimental interdisciplinary research.

A key role in the measurement and assessment of interdisciplinary research is played by the polarity between theory and experiment. Speculative interdisciplinary research seems to enjoy certain advantages in this regard. In fact, also in very recent and highly innovative fields this type of investigation soon takes on specific and clearly identified characteristics, thanks to the ideas developed by scholars which cause the problem originally investigated, and possibly the solutions proposed, to become crystallised within well-defined boundaries. This greatly facilitates the work of scientists performing the peer reviewing process. Consequently, the results of theoretical research are more easily published and their quantitative measurement proves much less challenging.

On the other hand, empirical interdisciplinary research might retain its complex and intricate characteristics for a longer time, thus proving less suited to peer

assessment by scientists other than experimenters. This is due to the fact that new practical problems must be addressed when building experimental devices, which might initially hinder the simple and linear assessment of the heuristic value of the ingenious solutions to measurement and verification problems devised by empirical interdisciplinary researchers.

3.2.5 Institutional obstacles to interdisciplinary research.

A crucial feature of interdisciplinary research is the fact that it is strictly related to new kinds of problems, external to the tradition of consolidated research programmes developed, at some point in time, through internal debates among the specialists of individual disciplines. The research programmes adopted by standard science within each of its branches present the scholars who conform to them with past problems and their solutions as well as with present problems that are accepted as relevant by the research community. As long as a scientist's activities strictly follow the currently accepted research programme (Kuhn, 1970), which is based, for the most part, on the discipline's recent past and present, the scientist will hardly be able to deal with genuinely new problems. Creativity and originality, which are two of the distinctive traits of the most talented scientists, would drive them to break the rigid boundaries that the general debate imposes on problems. On the other hand, standard science takes place within that debate and follows its directives. Therefore, it can be easily understood that standard science provides shelter from uncertainties about one's future career and academic survival, which are potentially threatened by an adventurous lifestyle revolving around extreme originality, within the highly competitive world of research. All of the above obstacles hinder the activities of scientists who wish to perform interdisciplinary research. In order to compensate for such an adverse context, academic institutions should intervene by modifying their incentives, supporting both the allocation of funds to interdisciplinary research and the opening of academic positions within this field of investigation (said academic positions might also be temporary, given the fluid and transient nature of interdisciplinary research in general). As far as measuring research is concerned, merely identifying the portion of work which scientists officially devote to interdisciplinary studies might lead to underestimating their actual efforts within the interdisciplinary fields, which means underestimating the research input in this sector.

3.3 Peculiarities in the quantitative measurement and assessment of interdisciplinary research.

This brief description clearly shows that the measurement of scientific activities within the field of interdisciplinary research can only partially follow the customary methods of scientometrics applied to individual disciplines (Porter and Rossini, 1985). In order to measure and assess interdisciplinary research, it is crucial to devise specific parameters. When choosing these parameters, the peculiarities of interdisciplinary research must be taken into account, along with the consequences that said peculiarities have on the procedures adopted by scientometrics, i.e. the procedures used to condense purely qualitative entities, such as ideas, into

quantitative measurements, such as the number of publications or citations.

4. INDICATORS TO MEASURE RESEARCH BY MEASURING THE PROBLEMS IT ADDRESSES.

The quantitative measurement of research output and its assessment in the case of interdisciplinary research are affected by a very different context from that characterising specialist disciplines. In the latter case, scientists usually aim to solve problems about the nature and relevance of which there is wide consensus within the research community, providing answers based on methodologies and principles that are already broadly accepted by most of their colleagues. Drastic and sudden changes in the methodologies adopted and problems investigated may indeed occur, but this is an exception rather than a rule in specialist research.

In the case of interdisciplinary research, the opposite tends to be the norm: the matters being examined, and sometimes also the methods used for their study, are radically new. This can occasionally depend on the intellectual curiosity of some interdisciplinary researchers, but it is more often linked to the fact that the problems investigated originate from outside the scientific community, for instance from military needs or from the needs of society in general (such as those concerning the environment). These radically new problems – which do not fall within standard science and have thus hardly been dealt with by already existing scientific disciplines – are then presented to researchers through channels and institutional organisations which are very different from traditional academic ones. Rather than by university departments, interdisciplinary research is often organised and commissioned by private companies and by non-academic public scientific bodies, such as state research agencies.

All the above must be taken into account when applying scientometric techniques to interdisciplinary research. In mono-disciplinary research, a central role is played by axiomatic solutions to abstract problems illustrated by scientists in journal articles. Furthermore, said articles are often the only result achieved by programmes focusing exclusively on specialist research.

Within interdisciplinary research, instead, specific problems, especially empirical problems, carry greater relative weight. Considering that the solutions to these problems regard extremely innovative matters – the ones usually investigated by interdisciplinary research –, it obviously becomes extremely difficult to provide quantitative output measurements and evaluations.

Nevertheless, the shift from general abstract answers to specific empirical problems, which is the objective of most interdisciplinary studies, turns out to be an advantage in the assessment of this type of research. When an interdisciplinary matter is submitted to scientists by companies or public bodies, said problem is often defined in a concrete way, which is easy to measure quantitatively. This happens in the case of a company or research organisation asking scientists to devise a new technology capable of reducing CO2 emissions by a certain amount, or a public agency for nuclear energy financing the construction of a tokamak device with certain characteristics, or an international health

agency requesting scientists to discover new drugs able to eradicate a tropical disease.

In all these cases, the nature of the matter is clearly defined from a quantitative point of view, and this makes it possible to measure how fitting the solutions provided by interdisciplinary scholars are in order to come closer to the final solution of the problem. For example, in relation to magnetic confinement nuclear fusion, the task assigned to scientists might consist in achieving a certain plasma confinement time, the first step towards the development of a self-sustaining fusion reaction.

In all the situations mentioned above, concentrating on problems and on approaching their solutions in objective quantitative terms can allow for output measurement and assessment also in the case of interdisciplinary research. This can be achieved by using precision and efficiency parameters able to provide public policies and entrepreneurial activities with content that is as clearly defined and as rigorous as that of specialist research. Hence, in the field of interdisciplinary research it might be appropriate to tweak and integrate the standard indicators and measurement procedures normally used for the assessment of academic research within individual disciplines. This should be done by paying greater attention than usual to problems that are empirically definable in quantitative terms rather than to qualitative and abstract problems.

5. CONCLUSIONS

This paper addresses the matter of defining indicators for the quantitative measurement and consequent assessment of inter-disciplinary research. The key argument put forward is that, due to the peculiarities of interdisciplinary research in comparison to research in general, the criteria for its measurement and assessment ought to be tweaked. In particular, we argue that, when dealing with this field, rather than concentrating on the theoretical solutions reached by scientists and published in journals, the focus should be shifted to the definition of the practical problems proposed by stakeholders to interdisciplinary researchers. By tweaking the methodologies and indicators adopted in such a way, the measurement and assessment of interdisciplinary research can achieve a level of rigour and precision by no means inferior to that of the bibliometric procedures normally adopted for disciplinary research.

REFERENCES

Anzai T. et Alia (2012) "Holistic observation and monitoring of the impact of interdisciplinary academic research projects: An empirical assessment in Japan", *Technovation*, Vol 32, pp.345-57.

Apostel G. et Alia (1972) *Interdisciplinarity problems of teaching and research in universities*, OECD, Paris.

Crease R.P. (2008) "Recombinant science: the birth of RHIC", *Historical Studies in the Natural Sciences*, Vol 38, pp.535-68.

Feller I. (2006) "Multiple actors, multiple settings, multiple criteria: issues in assessing interdisciplinary research", *Research Evaluation*, Vol 15, pp.5-15.

Huutoniemi K., Thompson Klein J. et Al. (2010) "Analyzing interdisciplinarity: typology and indicators", *Research Policy*, Vol 39, pp.79-88.

Klein J.T. (2008) "Evaluation of interdisciplinary and transdisciplinary research: a literature review", *American Journal of Preventive Medicine*, Vol 35, S116-S123.

Klein J. T. (2010) *A taxonomy of interdisciplinarity*, in Frodeman R. et Alia (eds), *The Oxford Handbook of Interdisciplinarity*, Oxford University Press, New York.

Kuhn T. (1977) *The Essential Tension*, University of Chicago Press, Chicago.

Kuhn T. (1970) *The Structure of Scientific Revolutions*, University of Chicago Press, Chicago.

Lamont M. (2009) *How professor think: inside the curious world of academic judgment*, Harvard University Press, Cambridge Ma.

National Academy of Sciences et Alia (2005) *Facilitating Interdisciplinary Research*, National Academies Press, Washington DC.

Pfirman S. et Alia (2005) "Collaborative efforts: promoting interdisciplinary scholars", *Chronicle of Higher Education*, Vol 51, February,

Porter et Alia (2006) "Interdisciplinary research: meaning, metrics, evaluation", *Research Evaluation*, Vol 15, pp187-96.

Porter A., Rossini F. (1985) "Peer Review of Interdisciplinary Research Proposals", *Science, Technology & Human Values*, No 3, pp.33-38.

Popper K. (1963) *Conjectures and Refutations*, Routledge, London.

Popper K. (1983) *Realism and the aim of Science*, Routledge, London.

Spier R. (2003) "The history of the peer-review process", *Trends in Biotechnology*, Vol 20, pp.357-8.

Weingart P. and Stehr N. (eds) (2000) *Practising interdisciplinarity*, Toronto University Press, Toronto.

Working Paper Cnr-Ceris

ISSN (*print*): 1591-0709 ISSN (*on line*): 2036-8216

Download

www.ceris.cnr.it/index.php?option=com_content&task=section&id=4&Itemid=64

Hard copies are available on request,
please, write to:

Cnr-Ceris
Via Real Collegio, n. 30
10024 Moncalieri (Torino), Italy
Tel. +39 011 6824.911 Fax +39 011 6824.966
segreteria@ceris.cnr.it www.ceris.cnr.it