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Evaluation of research infrastructures in the Social Sciences and Humanities field. A proposal for a new approach

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Abstract

This work confronts the challenge of research infrastructure evaluation in Social Sciences and Humanities. Globalisation and data use are causing RIs to become more influential in the SSH. The European Union caught these new tendencies in its most recent plans for RIs development, as ESFRI. Brussels policymakers expressed an interest in the development of projects like OPERAS and DARIAH. The following work aims to underline the role of RIs in the SSH field and how it's possible to evaluate these programs. Taking inspiration from the works conducted in STEM infrastructures, we first define what an RI is, and then show the challenges posed by the evaluation of infrastructures in science. Moreover, we present a a viable methodology which could be able to capture the essence of the work conducted in SSH RIs. We end up showing the limits and possible conclusion that this line of research could draw.

JEL codes: H54, O31, O33, O38
Keywords: Research Infrastructures, Evaluation, Mixed Methodologies, SSH, Public Policy

1. Contemporary and Big science

Contemporary sciences face many challenges (Stock and Wagner, 2014), and further will come shortly. More complex the issues are, the more demanding the tools necessary to describe and analyse them become (Farago, 2014).
Natural sciences offer us a perfect example of this increasing complexity. If we look up astronomy, the example is clear. The recent lunch of the Webb Space Telescope offered the involved space agencies, such as NASA and ESA, the opportunity to look at the sky with a wide range of new sensors and cameras, which provided images and data priorly not available to them (Kalirai, 2018). The previous facility used for such observation, the Hubble Space Telescope, could not capture the same aspects of space environments due to its natural, technological limits. The possibility to discover more about the space frontier and its secrets is offered by using a complex, advanced system such as Webb. A new telescope allowed global scientists to gather data on the composition of nebulas and planets, the behaviour of celestial bodies and other prodigies of space which further advanced our knowledge of the galaxy.
Space telescopes are just one of the many examples we can have of how the tools used can influence the quantity, and quality, of the data, obtained and processed

(Mayernik & Al., 2016). The capacity of science to advance further over the years is offered by the facilities involved in the process and the research infrastructures that can support scientists and experts in their work (Zakaria, Grant and Luff, 2021).

The role of research infrastructures (RIs) in the Science, Technology, Engineering and Mathematics (STEM) field – i.e., astronomy, biology, physics, and chemistry – is well underlined by a peculiar yet exemplary facility: the European Organization for Nuclear Research, more commonly known as CERN. Located in Geneva, it is a perfect example of how fundamental an infrastructure can be in further helping the development of sciences (Florio, 2019).
The work at CERN helped shape the modern form of physics, supporting the discovery of once-theoretical particles such as Higgs' Bosons. CERN is not only an example of a well-known and functioning infrastructure but also an example of how it is possible to focus the efforts of different countries on a single project to create and provide tools inaccessible priorly. Catalano, Giffoni and Morretta (2020) explained well in their paper how such infrastructure can determine a substantial positive impact on the scientific community due to the chance to improve the accumulation of social and scientific capital in the epistemic community (Catalano, Giffoni and Morretta, 2020) of the involved scientists. The three scholars analysed the impact on the career of many early-career researchers (ECRs). In the case of CERN, the three scholars pinpointed how the work conducted by the ECRs at the CERN helped augment their social and capital skills and become a resource for their future careers. Analysing the wages earned after participating in the CERN programmes, the scholars identified how being involved at CERN was a "premium" feature to the curricula of the researchers, granting them a boost in their future careers.
At the same time, Florio (2019) described well how such infrastructure could lower costs and increase the accessibility to fundamental tools for many scholars. In his pivotal works (Cfr. Florio, 2019; Florio, 2016), he insisted on the possibility that infrastructures could have cascade, positive spillovers over the scholars participating in them. Starting from the CERN and facing the different programmes offered, the analyst showed how research infrastructures could help reduce the cost of publications of a paper, raising its notoriety and giving access to scholars – early and later in their careers.

In his analysis, it is possible to read how he decides to apply the principles of the economic Cost-Benefit Analysis (CBA) (Florio, 2019). Using this method, he tried to include potential spillovers derived from the work of experts and scientists, in our case, those employed in STEM. We will see later more specifically in which form Florio advanced his analysis. At this point, it is relevant to understand the difficulties the author faced in the long run. He pointed out how the evaluation issue of any RI is connected to the time frame in which we wish to consider our impacts (Florio, 2019). Using the example of the International Space Station (ISS), he highlighted how, since the beginning of the project in 1992, the disposal of the same station and the diffusion of the knowledge output production was a problem the organisers had to face, even if the mission end date was stated as late as 2024. In particular, the issue was the cumulative effects of the produced knowledge. An experiment on the

ISS is connected to a broad range of scientists, enterprises and organisations on Earth, which can access the results and use them to provide new answers to, for example, new agricultural methods (Florio, 2019). Each of the results is an impact which the ISS produced. It is difficult, Florio stated, to calculate the financial and economic output these connections create because they are vast both in time and space. In the NPV model, which Florio advances, time is a variable which must be considered. We will not dwell on how time can be inserted in the model and in which quantity, but we want to underline that time becomes a problem only because we are not limiting our analysis to financial issues. The economic CBA tries to adapt to the difficulty of showing and listing the effects which, beyond mere profit, a RI can have (Florio, 2016).

2. Defining a research infrastructure (RI)

Before discussing further how to evaluate a research infrastructure, there is an issue related to how it is possible to define it. A helpful definition – even if not the first in order of time - is provided by Cramer, Hallonsten, Bolliger and Griffiths in their paper of 2022, in which they define a research infrastructure as "basic physical and organisational structures and facilities needed for scientific work" (2022). This definition, as they explain, is derived from the concept developed by Capshew and Rader (1992) of dividing between the idea of "Big Science" and the "big science" as a frame. The discussion on Big Science is central in the debate concerning the evolution of sciences in the XX century. Rader and Capshew reflected on the role Big Science, as terminology and approach, had on the capacity of states to devolve enormous amounts of resources in attempts of a much larger scale than in the past (Capshew and Rader, 1992), both as the creation of new research infrastructures – i.e., CERN or the Hubble Telescope – and the development of new technologies – i.e., the Manhattan Project. The role of Big Science is not irrelevant in our approach toward the part of RIs in social sciences because Big Science is not a concept related only to the size of the attempts made by the scientists themselves (Capshew and Rader, 1992), but it is a political choice also. We can consider the attempts, which we will dwell on later, of the European Union into the development of a European Research Area (Zacharewicz &Al., 2018) and its consequential sub-projects – as the ESFRI – into the design of Big Science. In this case, Big Science in the European Research Area is a construction built on a fundamentally different interlinked helix (Ierapetritis, 2019), which sees academics as strictly related to civil society, the financial world, and the political order (Ierapetritis, 2019).

This definition of research infrastructure offers a colloquial but not exhaustive definition of a broad range of facilities and organisations which can fall inside the frame of research infrastructures. In this case, research infrastructure is a vast facility supporting the scientists' daily efforts.

The ESFRI documents themselves instead offer a more precise definition of research infrastructure. In this case, the description provided by ESFRI (2020) is as follows:

> «RI are facilities, resources and services used by the research communities to conduct research and foster innovation in their fields. They include major scientific equipment (or sets of instruments), knowledge-based resources such as collections, archives and scientific data, infrastructures, data and computing systems and communication networks and other tools essential to achieve excellence in research and innovation».

This new definition offered by ESFRI opens the field of infrastructures to different services which are usually crucial in the Social Sciences and Humanities (SSH) – i.e., data-frame, databases, tools, and repositories. The most recent roadmap of ESFRI offers a perfect example of the inclusion of more projects in the field of SSH, which potentially can be related to the work conducted in such area (ESFRI, 2021).

In SSH, the discovery of the usefulness of research infrastructure is a more recent trend than the classic STEM (Hallonsten, 2020). While in STEM, it is noted the necessity to rely on multiple systems to sustain the work of scholars and experts (Spinello, 2019), in the SSH, the fragmentation of the field – often divided between different disciplines and often between other countries – was an obstacle to the formation of transnational and even national RIs. The cost of projecting and maintaining this level's infrastructure posed an obstacle that the lack of interest did not allow to overcome.
More recently, a new trend emerged. SSH started to rely massively on quantitative data, which often requires tools to being visualized, calculated and analysed in an understandable, straightforward way. The significant calculus potential to perform complex analysis – i.e., mass network analysis on a database with hundreds of thousands of entries, multiple-regression model and panel data covering centuries and hundreds of cases -the more this field discovered the necessity to rely on new facilities and tools capable of supporting new experiments and new research (Čeginskas, 2019).

The new role RIs have in SSH started principally with the mathematisation of SSH. The more data and formulas diffuse in the field, the more the SSH scholars also need the support of informatic tools to respond to new, complex questions. Another necessity SSH faces currently are the more diffused interconnection between scholars belonging to the most different institutions and usually far from each other (Mosbah-Natanson and Gingras, 2013). As in many other fields, SSH had to cope with the trend of increasing internationalisation to face the emerging issues of a globalised world, requiring the same transnational approach to face them (Heimeriks and Vasileiadou, 2008).
Like many other fields, the social sciences and humanities had to deal with the new digital tools and powerful instruments which changed and reshaped the approach such areas must have with the data (Giannoutakis and Tzovaras, 2017), their production, sharing, and usage (Heimeriks and Vasileiadou, 2008). In the digitalised world, data for social sciences come from the most different sources (Mosbah-Natanson and Gingras, 2013), such as social media and networks. They are provided

by many stakeholders and actors – i.e., private actors, public agencies, and non-governmental organisations. In the field of e-research, data are a fundamental resource. As we can see inside ESFRI, SSH must deal with new sources of information. At the same time, there is an ongoing attempt to convert the old, "classical" sources and elements into digital archives (Čeginskas, 2019). It is the case of DARIAH-ERIC, one of the many RI presented in ESFRI, involved in a project aimed to generate comprehensive, diffused archives of digital information, built to conserve, and allow the mass diffusion of documents and sources concerning art in Europe.

RIs come to support SSH in dealing with the always-increasing amount of data they have access to. In the digital era, it became necessary for scholars to deal with access to the information they need to support their works (Lane, 2019), as much as how to share them with other scholars in the name of the principles of transparency and open access to information (Liu and Li, 2017). Not less relevant, how to conserve such data is another issue that will be necessary to face soon.

Another support SSH RIs provide is in the publishing phase, creating space for new publications and offering the possibility for the published work to get credit and reference in a wider audience, following models as the Open Access one. In an environment which supports the "publish or perish" mentality (Hatch and Skipper, 2016), the possibility to have a support in facing the challenges offered by the field is invaluable.

Other than that, RIs can grant the chance to create new and more stable networks between scientists and scholars from different universities and institutes (Maegaard, 2018). RIs can also create the possibility of new links between various field inside the SSH themselves. In few words, RIs are becoming the links between stakeholders, scholars and policy makers.

The necessities we presented, which arose in the last decades, in particular, requested new tools – the RIs themselves. As much as in the STEM, in SSH, it was necessary to rely on a new generation of instruments and tools (Heinemann, 2018). Despite that, there are still strong differences between RIs in STEM and SSH. In the first field, we find physical infrastructures – as the aforementioned CERN – research laboratories and instruments. In the latter field, instead, the particularities of the work conducted, and the peculiarity of the academic environment sustained the development of SSH as more decentralised and digitalized.

Marking some examples, we discuss creating shared databases and informatics structures aiming to contain a considerable amount of data, as in the case of DARIAH. At the same time, we can see infrastructures whose primary goal is generating a space for cooperation and assistance, as in the case of another infrastructure, OPERAS (Heinemann, 2018). These are just examples extracted by the ESFRI Roadmap, which shows us some possible ways through which SSH RIs can affirm themselves. The roadmap is the tool ESFRI provided to show the evolution of the RIs presented and how each project evolves year after year. The roadmap, the latest launched in 2021, presents for each project the goal, the stakeholders involved, the phases of the project and the future outcomes. Besides, the roadmap describes how the entire ESFRI project, in its totality, is evolving. The edition of 2021 suggested, for example, how to adapt the current RIs programmes

to support post-pandemic recovery plans (ESFRI, 2021) and how to face the ongoing climatic challenges which are as never before central in the public discourse.

3. Evaluating RIs

Despite the similarity in the scope, the differences in how the RIs are developed become relevant factors when we are tasked with the necessity to evaluate the success and usefulness of RIs.
We had seen before how the works of different scholars (Cfr. Florio and Sirtori, 2016; Ecchia et Al., 2021) tried to focus on the quantitative analysis of how an RI can be, in the first place, evaluated at all. Some of the primary methodologies implemented fall into the category of cost-benefit analysis. Exploiting this methodology, the scholars tried to analyse the impacts provoked by the RIs in a way not dissimilar from the research usually conducted to face the costs and benefits of infrastructures in other realities – i.e., in mobility.
This can be true mostly when we face physical structures such as the laboratories funded and built in the STEM. Considering the limits they face in their works, their analyses, in any case, can capture the advantages and the cascading effects such RIs can have (OECD, 2021).
Performing a similar analysis on an SSH RI case is quite different. First of all, this kind of infrastructure received much less attention in the years – with only a renewed interest in the last period thanks to other policy changes and new investments (van Elzakker and van Drooge, 2019). At the same time, we face much more significant difficulties in defining the costs and benefits of such RIs.
In the work of Ecchia, O'Leary and Messori (2021), we can find a first-of-this-kind approach to analysing a research infrastructure fully immersed in the world of SSH. EuroCohort is a peculiar project that aims to create a database and generate data useful to analyse an entire cohort of European citizens born around the '20 of the XXI century and up to 2050. It is one of the most comprehensive longitudinal studies produced by the European Union and generally in the social sciences field.
The main aim of EuroCohort is to provide scholars with a set of data valid for a vast array of different analyses to conduct. In their paper, Ecchia, O'Leary and Messori applied the usual technique of the cost-benefit analysis to face the impressive task of evaluating *ex-ante* the massive project of the European Union.
As pointed out, this method raises a series of issues:

> «Among those, the main ones are: the need for a comprehensive approach (taking account of all valued effects in predicting net benefits) approach to assessing social policies; the need to recognise and explicitly address the great uncertainty in prediction and valuation involved in applying economic evaluations in most social policy areas; the need to consider those behaviours, which occur frequently in social policy, that do not satisfy the assumptions of neoclassical welfare economics, and the application to policies that often have strong distributional goals and consequences» (Ecchia, O'Leary and Messori, 2021)

The three authors focus mainly on the side of the RI developed to sustain the well-being of children and programmes created to use better the resources destined for childcare programmes and school actions. Focusing on such programmes, they were able to advance some possible methodologies practical to face the cost-benefit analysis of a programme such as EuroCohort. They pointed out the advantages of relying on a single data source and the possibility of sharing them in a viable model usable by most different institutions simultaneously (Ecchia et Al., 2021). So, two clear benefits are revealed by the scholars: a cut of the costs to access the data – and, consequently, to perform other research; the production of standardised results which can be viable to the most different experts and people.
The effects of the RI are focused on the public sector investing a certain number of resources in such a project and on the consequences for the social scientists involved in studies connected to EuroCohort.
We can see another attempt to evaluate the costs and benefits of infrastructure, even if in a very different field. In the work of Battistoni & Al. (2016), we have a deep analysis of the effects and the outcomes – both for the scholars and external stakeholders – of the Italian National Hadrontherapy Centre for Cancer Treatment (CNAO, in Italian). In their work, the scholars face the challenge of calculating the costs and benefits of an infrastructure operating in the healthcare system with a mix of *ex-post* and *ex-ante* analysis. In this case, the experts try to focus on the possible effects such infrastructure can have. In their case, they keep an eye on the knowledge output produced by the infrastructure; the technological spillover, the human capital formation provided; the cultural effect outreach realised; the benefits provided by the infrastructure's services to its users.
In this case, the writers try to underline how infrastructure can connect with a vast social and geographical tissue around itself. The idea behind the cost-benefit analysis is taken exactly from the same experimental studies of Florio & Al. (2016). It is considered that several benefits can come from the interaction with the stakeholders and the users, who find themselves linked in an ecosystem that provides them with different advantages. In the case of the CNAO, the effects can be directly linked to the user's health care or connected through medical tourism (Battistoni & Al., 2016).
The writers also attempt to underline how the infrastructure is inserted inside a specific network of business enterprises and other institutions. The work conducted at the CNAO, as the authors point out, is "highly collaborative", describing how the experimental works undertaken in the centre can become pilot programmes for other institutions and, so, a considerable saving of resources for many of them (Battistoni & Al., 2016). The spillover realised by the CNAO can give life to different activities in the territory and create new connections with other research centres. In the end, it becomes a significant source of saving for both the infrastructure and the affiliated institutions (Battistoni & Al., 2016).

The study of Battistoni & Al. (2016) moved forward from the basis provided by Florio, introducing some of the local effects such RIs can have, even if not focalising directly on them. We can define a local effect by describing it as the capacity of an RI to have an outcome visible in an urban or rural area where an institution is located. The local effects are not linked directly with the capacity of the institution to create knowledge or with its efficiency.

Works such as Florio (2019) observe if a policy to create or improve existing research infrastructure focuses much more on how the single institution reacts to it. In his pivotal opera, Florio (2019) showed how to apply the CBA to different contexts, trying to underline different costs and benefits which each single RI have to face. A fundamental difference Florio introduced in its work, is the difference between financial impacts and the economic costs and benefits of an infrastructure. Financial are considered all that indicators which are strictly connected with the cash-flow of money – i.e., the salaries of the scientists and the researchers. At the same time, under the label of "economic", Florio introduces different indicators which try to encompass the complexity of RI. Despite limiting himself to the specific field of STEM, he underlines how the costs and benefits include not only directly the infrastructure itself, but also the reality around it. Some of this complexity remains outside the analysis – i.e., the local effects -, while some of the effects can be analysed through specific tools (Geels, 2002).

While the kind of analysis proposed by Florio works fine for centralized and physical RI, some problems could emerge when we are instead focusing our attention toward decentralized and digital systems. RIs of the SSH have still strong physical anchors. Institutions involved in them have headquarters, offices and buildings in cities and towns. Especially when we talk about the SSH RIs, most of them are the centre of a network and of connections, involving actors and stakeholders which share the costs and the benefits of the RI itself (Spinello & Al., 2021).

Because research institutions are usually rooted inside the borders of towns and municipalities, it is not bold to sustain that it is possible that such institutions can build a cohesive and robust network composed of the actors belonging to the city's political and economic scene (Sennett, 2018), but not only. At the same time, universities and research institutions become tethered inside the social tissue of a city – or a region - between the different stakeholders involved in the activities which spawn all the latitudes of urban reality (Segers, 2016).

It has become customary to observe a certain number of interconnections between institutions devoted to creating innovation and generating change and all the actors who can be protagonists of such change (Zukin, 2021). We have seen in the economic evaluation of policy projects that the analysis of spillovers – from direct to indirect effects on the market or the regions targeted – can be a fundamental piece of the complex puzzle of the analysis. The same can be seen when we analyse the innovation policy programmes, such as the one which aims to reinforce the existing RIs and generate a new one. If we look at RIs as networks, we can consider the actors and stakeholders involved as part of the wider structure and, at the same time, as recipients for change and impacts – and also, engines of it.

The networks we can see around the infrastructures of ESFRI are two: one is the network composed of the institutions which are part of the project; the second is the network composed of the stakeholders interested and affected by the participation of an institution in the ESFRI.

We expect to observe indirect and direct spillovers generated by the RIs, which cascade into both networks. We can divide them into four categories:
Increase the calculus capacity of the single institutions entering the RI;
Refine the local academics' and experts' capacities, granting them the possibility to connect with a broader audience but also accessing more connections on non-local scales;
RIs should be able to connect the scientific community, improving the capacity of cooperation between different ones;
The RIs could have a spill over effect over the bottom-up network construction capacity of the local stakeholders and actors, who find themselves inside a more extensive network.

These four elements circle around the two different networks. An institution joining DARIAH could expect to perform better because it can rely on more advanced tools. One joining OPERAS can hope to connect to a broader audience. At the same time, participating in DARIAH or OPERAS can grant access to knowledge and expertise previously inaccessible to local scientists and scholars, which, even if not directly part of the institution in the RI, can count on seminars, courses, classes, which are known and now part of the local tissue.
These elements are part of the spillovers the RIs can have and are not always present in the cited CBA. For this reason, as we will see in successive paragraphs, the methodology we propose will focus on the tools provided by the Social Network Analysis (SNA) and counterfactual methods, which seems to offer a better instrument to analyse the reality of an SSH RIs (Coscia, 2021).

In our framework, we are considering the institutions as strongly linked with the space around them, as seen in the perspective of the regional systems of innovation (Segers, 2016). Regions are cohesive spaces where different kinds of stakeholders share goals and compete for resources and opportunities. Regions are a peculiar space of policing. First of all, because they are not always normative spaces which can be considered for analysis but geographical realities which can transcend political borders, they are transformed into normative elements by the action of political actors such as the European Union (Coenen & Al., 2015).

A conceptual definition of regions, applied in our case of innovation, is the regional system of innovation (RSI), as described by Cooke and Schienstock (2000) as a "geographically defined, administratively supported arrangement of innovative networks and institutions that interact regularly and strongly to enhance the innovative outputs of firms in the region". It is not dissimilar from the definition provided in 2005 by Asheim and Gertler of RSI as an institutional framework supporting innovation. In this sense, RSI offers the side, as a definition, to different criticisms, which focus on some grey spaces of how it is possible to define the regions and their qualities (Uyarra and Flanagan, 2010). RSI focuses much on the "static images" of reality, often without considering the different possibilities offered by the change in time and also in the spatial relationships between the actors involved in a certain territory.

In the case of research infrastructure, a definition of the region as a target of policy (Uyarra and Flanagan, 2010) can appear more useful to understand the relation between the institutions part of an infrastructure and their physical reality. Regions, as policy targets, can be local, national, or international on the governance scale, transcending political borders but also agglomerating stakeholders of different kinds and sizes (Oliveira and Natário, 2016).
If we reason on the side of the institutions part of a RI, it seems clear that the goal of the ESFRI RIs, especially the one in the SSH, is to link stakeholders who reside inside the same region, not always as a normative element itself. If the push the RIs move is toward better integration of these stakeholders, at the same time, we cannot not consider also the urban frame of reference. As Sharon Zukin pointed out in her work (2021), cities can become incubators of innovation due to long innovation processes and policy governance to enhance their capacity to attract talent, firms and financing start-ups. We can hypothesise similar impacts are possible even when, facing the lack of a public policy, research actors autonomously join a greater network – such as the one of an RI – to enhance their capacities.

4. Possible case studies

To better understand how RIs can have several impacts on different levels, a case study is helpful to analyse the practical side of their existence. A peculiar case is offered to us by ESFRI, the *European Strategy Forum on Research Infrastructures*. ESFRI was launched as a comprehensive programme by the European Union to sustain innovation and research within its border (ESFRI, 2020). ESFRI, as part of the greater European Research Area, is a massive-scale attempt to renovate the infrastructures in the continent, supporting the creation of new consortiums and partnerships between the member states and their institutions (ESFRI, 2021). ESFRI aims to reshape the operative framework presented in its roadmaps.
Interestingly, it is the presence of many projects belonging to the SSH field, a new approach if we consider the past attempts to reason on massive scale efforts of new RI. It introduced a new design of RIs which covered the different needs of researchers around Europe. Some of the projects presented in the most recent ESFRI Roadmap comprehension attempt to generate new calculus capacity for the researchers in the continent – as we can see with both *SLICES* (Scientific Large-scale Infrastructure for Computing/Communication Experimental Studies) and *SoBigData* (European Integrated Infrastructure for Social Mining and Big Data Analytics). Both these projects entered the ESFRI Roadmap in 2021 and are expected to be operative in 2024-2030. Both are decentralised and aim to enhance the calculus capacity, data usage and organisation for many different actors.
ESFRI is divided into sections covering a specific terrain of science and research. The roadmap is divided into Social and Cultural Innovation, Health and Food, Energy, Digit, Physical Sciences and Engineering, and Environment. For each of these sections, we can see new projects – entered in 2021 in the roadmap – and older infrastructures, either launched or in a more advanced stage.

We are interested in the infrastructures in the section Social and Cultural Innovation. This compartment aims to expand the capacity of the Social Sciences and Humanities to face the current and future challenges which European citizens will endure in the next decades (ESFRI, 2021). Other than the fundamental role of supporting the institutions belonging to the SSH – i.e., museums, archives, libraries, universities - this entire field of sciences will be fundamental in supporting the transition toward a greener and more sustainable system of production and consumption (ESFRI, 2021). SSH is a fundamental passage to understanding society, its development, and its change. The capacity of institutions to rely on better infrastructure to gather and analyse data become so fundamental for any strategy – such as the Recovery Plan, the European post-COVID strategy.
Between the landmarks and projects advanced in the most recent roadmap of 2021, two infrastructures could be case studies for our next study: OPERAS and DARIAH.

OPERAS, "Open Scholarly Communication in the European Research Area for Social Sciences and Humanities", is a project focused on the diffusion of works and papers via transparency and new open protocols for disseminating knowledge. An extensive SSH infrastructure, the main goal of OPERAS is to create and favour the condition for scholars to share their competencies and expertise with other scholars from all over Europe and beyond. OPERAS is divided into national nodes, - most of which are in the process of being implemented at the date in which this paper was written -, each coordinated by an institution of the member state that aims to participate in the programme. At the same time, each node is built as a network connecting the stakeholders and actors involved in the publication field, in disseminating knowledge and, of course, in its production.
OPERAS offers a common ground for research institutions and European groups involved in the SSH field. Still, it also works as a repository of data and standard practices to create a shared way to diffuse knowledge around Europe. As programmed and defined in ESFRI, tools present in OPERAS are, for example, GoTRIPLE, or "Transforming Research through Innovative Practices for Linked Interdisciplinary Exploration": TRIPLE is one of the projects OPERAS supports. In this case, it is formed by 19 partners from 13 different countries. At the centre of the program TRIPLE, we can find the tool GoTRIPLE itself. It is the platform, based on the Isidore search engine developed by the French National Centre for Scientific Research (CNRS), providing a single access point for users – i.e., researchers, institutions such as universities and libraries, but also private enterprises or service providers, media and consultancies.
GoTRIPLE aims to allow the people involved in discovering and reusing open scholarly SSH resources such as data and publications, which are usually divided into various repositories. GoTRIPLE, like many other tools, tries to compensate for the distortions present in the SSH field which are often connected with access to funds and the possibility to know new work and research opportunities.
Another example of the kind of tools OPERAS tries to incentivise is PRISM. In a time in which the transparency of the process is relevant to understand the quality of work (The Royal Society, 2012), PRISM:

«Collects the variety of peer reviewing practices from hundreds of monograph publishing houses, categorises, them, and provides a single access point to the list of certified peer reviewed monograph available in Open access in the world» (OPERAS Website)

OPERAS offers some peculiar tools that can be useful and differentiated in their impacts on scholars, but not exclusively. As a RI involved in the SSH, the potential outcomes and spillover of OPERAS can be appreciated by a plethora of people with various interests in the results of OPERAS itself.

But while OPERAS is in a "beta" at the moment, belonging to the set of infrastructures entering the roadmap in 2021, in which most of the tools are becoming just now operative and functional (ESFRI, 2021), there are other infrastructures in the SSH which are working at the entire regime. As we cited before, there are instead infrastructures still present in the roadmap which are currently ongoing. They are defined as landmarks, and one, in particular, can be useful for our analysis.

DARIAH ERIC is the Digital Research Infrastructure for the Arts and Humanities. Launched as European Research Infrastructure Consortium (ERIC) in August 2014, it now counts 20 members and several cooperating partners belonging to non-EU member countries (DARIAH website). DARIAH:

«DARIAH integrates digital arts and humanities research and activities across Europe, enabling transnational and transdisciplinary approaches. In particular, it provides value to its members and stakeholders through the validation and sharing of data, services and tools; by providing training and education opportunities; by enabling 'bottom-up' organisation around emerging research needs; and through the exercise of foresight and policy engagement.»

DARIAH aims to expand the capacity of institutions and stakeholders to integrate and develop new methodologies to study arts and humanities in new, exciting ways. DARIAH works divided into four Virtual Competency Centres (VCCs). Each covers a peculiar area for DARIAH: VCC1 is the main e-infrastructures, the backbone of the entire project. VCC2 is the Research and Education liaison, acting as the primary interface for eventual stakeholders and education actors. VCC3 deals mainly with Scholarly Content Management – i.e., creating new content, disseminating the tools, and so on. VCC4 focuses on advocacy, outreach, and impacts, interfacing the DARIAH project with other relevant stakeholders in arts and humanities.
The same website of DARIAH points out how the infrastructure is central in the digitalisation of arts and humanities and clarifies how it can have visible and relevant impacts in this field. DARIAH is devoted to changing how customers – visitors, in our case – can see, interact and enjoy arts and humanities products through the influence of the stakeholders, which are prominent actors in the field.
It is trying to change how we interact with arts and how we can use them to benefit our entire collective. Naturally, DARIAH tries to work as a network enhancer and creator, communicating with the most diverse actors employed in these various environments.

In different phases of their project life, both OPERAS and DARIAH offer insight into the future of RIs in the SSH field. A keyword of how they operate is decentralisation. The infrastructures we consider are not physical structures as customarily thought. They are connected to different institutions and rely on network structures and digital tools to work effectively.
As we have seen, in SSH, the situation is quite different from the STEM. Social scientists do not often need laboratories and equipment of certain dimensions. Most of the time, they need more calculus capacity and the possibility to connect or share their work with colleagues from faraway countries.
But even if the infrastructure is not an absolute, physical place, the institutions joining and financing it are. They are often universities, centres of research, and even institutions and associations somehow correlated to the scientific production environment, such as the associations of editors of scientific papers. Each of them is driven by different motives to join programmes such as the ones offered by ESFRI. Still, each one of the actors involved represents not only a fundamental part of the network but also a possible site of spillover effects of a different kind. The network created around the infrastructure is a fundamental part of the reality we try to analyse.

5. A possible methodological approach

We noticed how it could be not easy to understand and find all the possible impacts and spillovers a RI can provide when we are in the SSH field (European Science Foundation, 2011). We can recognise, at the same time, that such effects and spillovers are distributed among a larger share of the population in a theorised model in which the network built around the infrastructure is, at the same time, deeply connected to the network of actors and shareholders which daily interact with the leading institutions joining such RI.
RIs have, as their primary goal, to provide tools and instruments to amplify an institution's capacity to work and create science and innovation. But, especially in the SSH, innovation and knowledge are deeply rooted in a specific political, social, and cultural context (Beck & Al., 2022).
The effects on this share of the population, especially the urban population, are part of how it Is possible to calculate the outcomes and the value of a single RI. In SSH, we should also consider these possibilities.
For such reasons, our two RIs offer a perfect example due to their decentralised structures and aims. OPERAS is based on the idea that it is possible to create a network of agents and institutions to provide new, innovative ways to share materials and research among scholars from different parts of Europe – for free and following the principle of openness and transparency. DARIAH does not fall from the same tree, aiming to generate cooperative and coordinative spaces of action and production of knowledge themselves.

We are reasoning here on two different levels of impacts and spillovers: the impact on the local space and the one on the institution joining the network.

To analyse these two realities, we must find different approaches capable of explaining the reality we are facing. A possible tool coming to our aid is the Social Network Analysis (SNA). Aiming to understand how the presence of affiliated institutions can impact a city to a specific RI, the first level of analysis must focus on the network building around the infrastructure.
We know that each element of ESFRI relies on the national and regional node (ESFRI, 2020), a web of different actors and stakeholders interested in the development of the specific RI, which can offer scientific and practical support, and which are interested in the possible developed tools. While for DARIAH the nodes are formed, OPERAS – as said before, a project in its initial phases – offers us the possibility to observe the creation of the node itself, the process going from simple meetings to the establishment of a stable structure of collaboration. We have one node forming in Portugal – a country which also hosts a DARIAH national nexus in the form of a national consortium, ROSSIO. The University of Coimbra is the coordinator for this new node of OPERAS. The university, one of the oldest in the world, is renowned nationally and abroad as a top-tier scientific institution, offering courses in multiple languages and hosting students of more than 115 nationalities. It perfectly encompasses the kind of actors who can be enriched by joining and sustaining scientific networks.
OPERAS, in our Portuguese case, encompass the University of Coimbra, but also NOVA School of Social Sciences and Humanities, the University Institute of Lisbon – ISCTE-IUL, and APEES, the Portuguese association of editors of higher education schools. In Italy, other than universities such as Federico II or Roma 3, we have participant as Net7 or the editorial group Lexis.

It is clear that all the key stakeholders we can preliminary observe are deeply interested in the diffusion of scientific literature and knowledge, both as producers and editors. Some of them – such as the universities – are deeply interested in the opportunity to lower the cost of publications but also the creation of direct contact between their scholars and scientific magazines. At the same time, the latter are economic stakeholders that profit from the same scientific productions. We have, in this case, both reasons for the stakeholders to cooperate as much as compete with each other, at least from a preliminary analysis.
Here, the SNA methodologies can support the analysis of how the network is being created and the relations between the several stakeholders on the field. Our aim, in this case, is to understand the kind of network generated by such efforts and the kind of actors taken into consideration and dragged to sustain it.
Not less relevant is for us how, at the same time, such actors are connected on the same topic with stakeholders outside of the network itself. We aim to analyse the impacts of an RI on local space. It will be fascinating to explore how each node of the larger infrastructural network is connected not only with the others but also with an array of smaller actors and stakeholders. These latter operate on the local scale – i.e., the urban reality – and are potentially interested in the infrastructure and affected by it at the same time.
Let's consider a quadruple helix model (Carayannis and Grigoroudis, 2016), which can effectively describe the condition of the relations between the different actors devoted to policymaking in a certain urban landscape. It is not indifferent for us the

presence on the field of actors linked with civil society as much as with political actors and enterprises enriched by the tools promoted by, in our case, OPERAS.
For the policymakers, for example, accessing more knowledge resources in open and transparent access can mean lowering the costs to gain externalised competencies and expertise. There are many possible spillovers for an infrastructure whose main goal is effectively diffusing itself the possible outside of the classical boundaries of the scientific community, bridging the gap in the helix we considered before.
Creating new links and relationships between players who work on the same issues and problems can generate new synergies outside the RI's natural limits and its activity, as it happens with the epistemic communities of experts (Davis Cross, 2013).
Hypothesising a relevant role for the network itself in granting the success of the RI and disseminating positive spillovers around a community – not only the epistemic community of the experts involved but also the local communities around the institutions themselves – it becomes essential to understand how the network is built in the first place, which actors are considered to become part of it – in both the initial and late stage of the creation – and if the RI – OPERAS or DARIAH– can impact even outside of it.

At the same time, it is not less relevant to understand how the RI directly impacts the institutions joining it. For the experts, as we have seen in previous works, it is difficult to choose the indicators most suitable for such analysis, as much as get clear, useful data to underscore such results (Ulnicane, 2016).
Yet, it is a necessary effort. Research institutions could gain several advantages from joining an infrastructure, especially when such infrastructure is inserted into a reality as the one provided by the ERA or ESFRI. Some of them are economic – as seen in the works of Florio (2019) – but at the same time, it is possible to hypothesise every institution joining ESFRI could also see some direct impacts on its capacity to publish more, with authors coming from different institutions, getting access to more funds from calls and grants. Using a descriptive approach to SNA, analysing particularities such as centrality, weights, edges, and connections, we aim to reconstruct the network and its characteristics.
The SNA can provide us with insights into the structure, the kind of relationships generated between the actors, its extension and also the capacity of the network to activate and sustain the actors involved in the RI (Coscia, 2021).

But we are not only interested in describing the network itself. What matters for our work is also considering the impact the RI can have on the institutions and the stakeholders involved. In this case, counterfactual methodologies could be an efficient tool to support a comparative analysis aiming to understand if belonging to a network can be or is not a real game changer.
We listed four possible outcomes the RI could have over the single institutions concerning their knowledge-creation capacity and the formation of experts and scholars. We need, at the same time, indicators capable of describing such outcomes. In his paper of 2019, Wallis analysed how planning was a vital part of any research institution. Using the methodology of the Integrative Propositional Analysis (IPA),

he described how it was possible to see through funding, recruiting, staffing and productivity some indication of the well-being of a research institution – the IAMO, in the cited case – in a competitive environment which sees private and public actors all involved in the same run.
Despite the fact that the methodology Wallis used does not particularly fit for our specific study on RIs, the indicators he recognises can be useful for our analysis. Productivity is an interesting indicator of how the RI can impact the capacity of an institution to function better and correctly in its environment. At the same time, the idea of productivity is tricky. Not only on the pure theoretical frame, in which we could sustain the productivity of a RI could reflect on a long-time frame that an analysis conducted now will not be able to catch. There is also a problem with the quality and the quantity of data available. Different works focused on analysing the level and quality of production of an institution through the analysis of bibliometrics data (Cfr…). However, publications indicators of papers, books or chapters are not always freely available or directly accessible. The main platform – i.e., Google Scholars, SCOPUS, and Web of Science – present no consistent database. Universities, at the same time, have no obligation to put their data on those platforms, even though we can think of consistent systemic obligations which could push this kind of behaviour (Liu and Li, 2017). They can still provide some insights if efficiently web-scraped, but we could find more systemic databases in the RISIS system and other more structured public institutions.
Still, we can find some co-factors which could not easily be recognised for why a specific paper has a higher citation number in a certain period, for example. Despite these risks, citations and collaborations could be indicators capable of capturing the diffusion of a work, a book or a paper and understanding its diffusive capacity.

To understand better such an indicator, it can be useful to link it with the funding capacity of an institution, the eventual stuff assumed, the organisation and participation in conferences and seminars. In a few words, to analyse the evolution of a research institution, it is necessary to understand how the same institution places itself among other similar institutions.

6. Limits and conclusion

Concluding, this paper aims to introduce the topic of what is a research infrastructure – especially in the frame of the ESFRI program – and how it is possible to evaluate them. RIs in the world can be divided between physical infrastructures and digitalised ones. For the latter, when we are also talking about the SSH field, we face several difficulties in obtaining a correct, functioning, cost-benefit analysis. While some works, such as the one of Ecchia, O'Leary and Messori on EuroCohort (2021), shows how it can be possible to evaluate part of the benefits such RI can provide, there are still outcomes which we think should be possible to analyse.
ESFRI's projects exist mainly as networks (ESFRI, 2021), and as such, they should be faced with. Projects such as OPERAS and DARIAH have as their primary goal the creation of tools and instruments, unifying the energies and the efforts of

different institutions simultaneously. We can reason on two different levels: the institutional and the local.
The first, each institution joining an infrastructure aims to amplify its capabilities, implementing new strategies to compete better in a market of knowledge where many actors – private and public – fight for dominance (Mazzucato and Jacobs, 2017). Belonging to an RI could be an advantage in obtaining space and opportunities for publishing – the lifeblood of any institution – and creating innovation.
At the same time, the institutions are in a specific place – usually an urban one – where enterprises, political and social actors and stakeholders. Each one is connected to the university or the research centre for different reasons: partner, sometimes financer, sometimes being consulted by them for policy reasons. The contemporary city is also a reality which relies more and more on science and experts to face unprecedented challenges (Robinson, 2010). The more the complexity becomes intertwined in the tissue of an urban landscape, the more the experts become necessary, as much as structures and infrastructures capable of supporting their work.

To fully understand the capacity of infrastructure, we must move between these two levels and analyse how the institutions react to belonging to such systems. This approach, focused more on the institutional level, will face some limits. Some of the advantages an infrastructure has can be observed more at an individual level (Florio, 2019), which, in our case, will not be analysed properly.
To properly score an impact, we will also have to limit our analysis to the single departments and research centres – generally, stakeholders – with direct contact with the same infrastructure. We can imagine that the department of physics of a university will not have any kind of improvement due to the participation of its university in a program such as DARIAH. This will impact our data access greatly, seemingly because some are usually aggregated at the institutional level and not at the single departmental one.

On the same page, we will find limits on the possible causality of improving the institution's capacity linked with the infrastructures. We hypothesise that each university and research centre participating in ESFRI will improve its productivity and capacity thanks to the infrastructure. At the same time, we can also face a case of self-selection. The best departments and centres could also be the ones that, more than other institutions, decide to join such infrastructures. It can be possible that some of the effects we observe – i.e., a rise in the publications of inter-university publications – could be trends present in the institution from before the organisation of the infrastructure itself.
A third limit we will face is how we will observe the created network. Our attention will be devoted principally to the main node of the national network, such as the coordinator node. This, of course, means that we will not be able to see the effects on the peripheral nodes. In the future, if the model of analysis proves useful in analysing such cases, it will be possible to expand our point of view and see every single node, with all its particularities and specificities.

Despite these limits, we think this research could present some innovation concerning the precedent literature in how we approach the field of infrastructures in SSH. We are trying to expand our capacity to analyse how it is possible to understand the impact and how to perform an evaluation without only considering the economic side of these efforts.
In our attempt to look at the institutional dimension and the dual network level – one of the infrastructures and the one on the local side – we are inserting more complexity in the analysis, mixing up two methodologies, the Social Network Analysis, and the Counterfactual methodology. We anticipated why SSH is an unprecedented case and why the infrastructures, such as OPERAS, present more difficulties than others – like the CERN. Their decentralised nature diffuses the costs and the benefits. It also makes it more difficult for the cost-benefit analysis to work correctly.
We want to include in the analysis of the impacts a broader range of indicators which belongs more to the social reality and the innovative creative capacity of the single institutions, overcoming the initial limits of the CBA itself.

Concluding, in this paper, we tried to define and see how in the past, research infrastructures were evaluated (Florio, 2019), particular in the STEM field, and how only recently have more studies appeared trying to focus also on the efforts in the SSH (Messori, 2021). Research infrastructures are increasingly the backbone of research efforts in Europe and beyond.
The current analyses focus much on the economic aspects and sides of the problem – trying to find supporting evidence for any investment from the side of the policymaker. While the economics of infrastructure is a necessary evil, at the same time, the benefits could be more diffused than initial thought. Especially if we talk about the results of knowledge creation in SSH, the effects should be seen in the academic environment and the local reality that hosts them. Political actors and social stakeholders often rely on the tools provided by experts to operate better. There is the possibility that better-trained advisors could foster the enterprise capabilities of a city, the adaptation to new technologies or improve the social tissue of a town.

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