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ON RELATIVE SUCCESS IN OBTAINING GRANTS FOR SMART CITIES IN THE EUROPEAN UNION AND ON THE COST OF THE OUTCOME

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Abstract

The concept of smart cities is gaining momentum with efforts to go greener and be more sustainable along with the growing demand for data-driven policies. The European Union (EU) is highly committed to fostering sustainable urban development through targeted funding programs that encourage innovation, collaboration, and practical solutions for climate-neutral and smart cities. We have used data mining on the data of the Community Research and Development Information Service (CORDIS) and Eurostat during 2014 – 2022, to analyze such projects. Firstly, we can report that in absolute measures, Germany, Spain, France, Sweden and Lithuania have obtained the largest amounts of money fromthe EU Horizon program to support the development of smart cities. Secondly, we have found that when accounting for the size of funding per capita, Estonia leads in terms of funds invested in smart cities followed by Luxembourg, the Netherlands, Finland, and Cyprus. Focusing our attention on the cost of outcomes, i.e., the efficiency of spending funds on smart cities, we can see that the leading countries in the EU are Romania, Switzerland, Norway, and Luxembourg. The authors have compared the success of European projects in their different phases, while considering the overall results as most relevant for our evaluation.

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Key words

- Smart cities,
- Project management,
- The EU,
- Funding, Horizon,
- Success,
- Data mining.

1 BIBLIOGRAPHICAL REVIEW

The European Union is highly committed to fostering sustainable urban development through targeted funding programs that encourage innovation, collaboration, and practical solutions for climate-neutral and smart cities. The European Union is actively supporting the development of smart cities through various funding programs. One significant initiative is the Horizon Europe research and innovation program for the years 2021-2027. The EU Missions is a novel approach within Horizon Europe and aims to address pressing challenges by delivering concrete solutions and tangible results by 2030. The goal of the Cities Mission is to make cities smart and climate-neutral, as they are key to reaching climate neutrality by 2050. This is essential because most EU citizens (75%) live in cities, which only cover 4% of the EU's land area. Globally, cities are responsible for more than 70% of the CO2 emissions and use over 65% of the world's energy. The Cities Mission wants to achieve 100% smart and climate-neutral cities by 2030 and turn these cities into hubs of innovation and experimentation, thereby encouraging other European cities to do the same by 2050.

There are many funding opportunities, and the estimated budget is more than €70 million (European Commission, 2021).The European Commission has been actively supporting the development of smart cities through its Horizon 2020

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research and innovation programs by which the European Commission has funded the Smart Cities and Communities Project Clusters. The aim of these clusters is to bring together various stakeholders such as cities, industry, knowledge institutes, and citizens to showcase solutions and business models that have the potential to be scaled up and replicated. The EU has supported the development of innovative solutions for cities that could improve the quality of life for citizens and tackle urban challenges by investing around €3.1 billion in research on urban sustainability and development under the Horizon 2020 programme (European Commission, 2020). The European Structural and Investment Funds, which include the European Regional Development Fund, offer financial assistance to EU regions for urban development projects, such as smart city initiatives.These funds aim to reduce regional disparities and promote sustainable growth (European Commission, 2020). Caragliu et al. (2021) have stated that the Cohesion policy also plays a significant role in funding smart cities with a focus on improving infrastructure, innovation, and environmental sustainability. The policy's goal is to enhance the economic and social integration of EU member states.

Galati (2018) argues that implementing smart cities is not inexpensive. It requires a strategic and comprehensive plan to secure funding for individual smart projects or entire programs. Investors seek a clear understanding of the potential return on their investment before committing funds. Meanwhile, municipal bodies aim to enhance technology, mobility, and system capabilities to maintain the attractiveness of their cities.

Clerici et al. (2019) note that the European perspective on smart cities encompasses diverse visions, social goals, and data-driven approaches to enhance urban living. The European vision of smart cities is not uniform; it varies based on the diverse realities and perspectives of European citizens. European cities aspire to be more than just technologically advanced, they aim to be platforms for social progress, democratic dialogue, cultural diversity, and environmental regeneration. Data-driven transition is one of the key elements in the creation of smart cities. Over the last decade, cities have transitioned toward becoming smart cities, and data from information and communication technology applications play a crucial role in understanding, analysing, and planning cities for improved efficiency and equity.

Orejón-Sánchez et al. (2022) mention generational shifts that reflect the dynamic evolution of smart cities, from technology-driven initiatives to comprehensive, multi-dimensional approaches that consider various aspects of urban life and sustainability. The main focus of current smart city concepts is the inhabitants and societal goals, and they have the following dimensions: social cohesion and governance, smart city platforms, urban planning, international outreach, software (apps and websites), mobility, technology, the environment, and human capital.

Trindade et al. (2017) tried to understand the relationship between environmental sustainability and smart city concepts. Through a systematic review of the literature, the authors examine sustainable development in smart cities and provided the baseline idea that smart cities emerge from the intelligent use of digital information across various domains (health, mobility, energy, education, governance) and that sustainable urban development aims at the use of renewable resources within smart cities. Their review sheds light on the intersection of smart cities and sustainability, thereby providing valuable knowledge for future research and practical implementation.

The concept of an integrated smart city has been explored by Attaran et al. (2022). They claim that current smart city models do not have ideal solutions for integration and that aspects such as security and the information and communications technology infrastructure (ICT), created in a society are not fully incorporated. They suggested that new sub-components and extra-components are required for a comprehensive structure. They introduced an improved general model with six components: smart people, smart government, smart environment, smart transportation, smart economy, and smart life. These components are meant to ensure the integrity, dynamism, flexibility, and performance of a smart city, as well as to facilitate life cycle management and enable the better prediction and prevention of events such as natural disasters and pandemics. The model aims to address the integration challenges for sustainable urban development.

Javidroozi et al. (2023) has run an extensive review of smart, sustainable, and green cities and declares that smart cities should be integrated and collaborative. Their key points include a shared vision of all stakeholders, an integrated creative approach based on urban planning that fosters synergies across sectors and minimizes negative trade-offs, societal well-being and equity, and the incorporation of a green and blue infrastructure. Public–private partnerships can secure resources for smart, sustainable, and green city initiatives. Myeong et al. (2022) provides a comprehensive analysis of smart city research over the past decade (from 2011 to 2020). The authors emphasize that rapid urbanization has intensified the need for smart cities that can tackle problems invovlving transportation, the environment, welfare, the economy, safety, energy, and resource distribution. They note that future cities can benefit from data-driven applications for performance efficiencies, climate mitigation, and the well-being of citizens. Furthermore, by using data innovations, workplace paradigms and environmental biodiversity can be stimulated. Addressing security and privacy concerns is critical for responsible data handling, digital literacy, and online connectivity. Access to real-time data is crucial, especially during pandemics and other disasters.

2 INTRODUCTION

Smart cities have acquired a higher degree of relevancy since the technology has become a greater part of our lives. In recent years, governments, researchers, and the private sector have been investing heavily in smart cities. Ismagilova et al. (2019) has noted that smart cities are gaining in importance because of the rapid growth of the population in today's cities in a close connection with persistent advances in technology. Thanks to the increasing annual expenses of the municipalities themselves, which are cofinanced directly from state budgets or from the budgets of supranational entities with the generous cooperation of the private sector, there is an acute need for systematic research into the concept of smart cities, which can lead to the further development of this concept.

2.1 Characteristics and definitions of a smart city

With the growing role of contemporary cities as well as the irreplaceable role of technology in our lives, the concept of "smart cities" is gaining public attention. According to the European Commission, a "smart city" is a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and businesses. A smart city goes beyond the use of digital technologies for better resource use and fewer emissions. It means smarter urban transport networks, upgraded water supply and waste disposal facilities, and more efficient ways to light and heat buildings. It also means a more interactive and responsive city administration, safer public spaces and meeting the needs of an aging population" (European Commission, 2023). Countless smart city definitions can be divided into groups according to the professional focus of a specific group; nevertheless, we still lack a definition of a smart city that legally matters. This term is currently more prevalent in technical and economic fields of the sciences than in terminology intended for the legal sector.

There is an approach to constructing smart city definitions on various bases that give information and communication technology an irreplaceable role in constructing and connecting other functional qualities of a smart city, such as the joint definition from the International Organization for Standardization and the International Electrotechnical Commission: "An innovative city that uses information and communication technologies (ICT) and other means to improve the quality of life, the efficiency of urban operations and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects" (The International Organization for Standardization, 2014).

Caragliu et al. (2009) adds another holistic definition, which highlights other tools and characteristics of the conceptualization of a smart city, while maintaining the importance of ICT, stating that an urban area might be determined to be "smart" when factors like human and social capital with the modern ICT drive for economic growth, which is sustainable and has a good quality of life, is coupled with a clever management of resources on the one hand and collective participatory governance on the other hand.

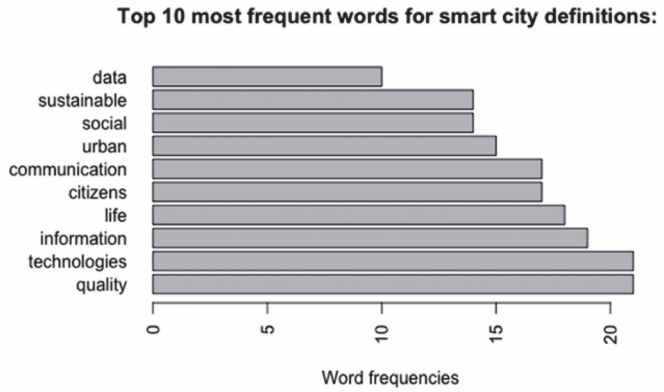


Fig. 1 *Word Frequency Plot Generated Using Compiled List of Smart City Definitions*
Source:https://doi.org/10.3390/smartcities6040080

According to Gracias et al. (2023), the results of the word cloud analysis shown in Figure 1 clearly demonstrate that the quality of life for inhabitants in cities is a criterium whitch plays a significant role when creating smart city definitions.

The leading position of the placement of the terms "technology" and "information" in Figure 1 highlights the importance of ICT as a primary factor in the implementation of smart city projects. Despite the unequivocal prevalence of individual terms in smart city definitions from different authors across the smart city sector, according to the subject analysis conducted by Gracias et al. (2023), smart cities lack a generally worldwide recognized definition.

2.2 Smart cities in the context of global investment

Even though the division of the investment domains of the smart city concept varies from source to source, we can state in general that the development and implementation of the smart city initiatives typically require significant investments in several areas. According to www.statista.com, "the global smart city market value will be worth approximately $1.38 trillion by 2030, while in 2019, it was only $392.9 billion" (Statista, 2021). Over the last ten years the European Union has distributed 1.32 billion EUR via its funding programmes into various smart city projects totalling 1.77 billion EUR overall investments (European Commission, 2023). The scale and scope of the investment can vary significantly, based on the size of the city, its existing infrastructure, the specific technologies being implemented, and the extent of integration. Governmental funding, private sector partnerships, and public-private collaborations often play a significant position in financing smart city projects. The long-term benefits of such investments are typically seen in the increased efficiency of city administrations on the one hand, thereby leading to improved public services, coupled with a better and healthier life for its residents on the other hand. Furthermore, net zero plays a central role in smart city projects and their further development. The European Commission has revealed a mission platform, the main objective of which is to prepare and accomplish 100 net zero smart cities by no later than 2030. There has already been a selection of 100 cities in the EU and 12 other cities in countries associated with Horizon Europe aiming for net zero by 2030, involving the testing of multi-sectoral approaches and applying the stakeholder engagement and management model whilst internally governed. Looking to the future, successful smart cities will play the role of innovative centres and will spread their innovations among the other European cities to achieve climate neutrality by 2050, which is the main goal of the European Green Deal (European Commission, 2023). Investments in large smart city projects require careful planning, strategic partnerships, and the prioritization of key areas to achieve success.

2.3 Smart city rankings and their meaning in smart city funding

With the rise of the smart cities concept and the subsequent competition for funds that flow from various sources, the level of the smartness of cities based on various rankings

has experienced a boom and attracted the attention of professionals from this area as well as the general public. There are countless ways as to how to evaluate smart city models, as well as a wide range of outputs from evaluations anchored in the form of smart city rankings. The methodology for ranking smart cities varies, depending on the organization conducting the rankings or the study.

For instance, the IESE Business School's Center for Globalization and Strategy looked at 174 cities around the world and analyzed them across nine metrics: "human capital, social cohesion, the economy, the environment, governance, urban planning, outreach technology, and mobility" (IESE Business School's Center for Globalization and Strategy, University of Navara, Spain 2023).

Similarly, the Smart Cities Index Report 2022 analyzed 31 smart cities using categories such as "service innovation, urban intelligence, urban sustainability, urban openness, infrastructure integration, urban innovativeness, collaborative partnerships, and smart city governance" (Institute for Manufacturing, University of Cambridge, and Digital Transformation Research Center at Yonsei University, China 2022).

Respectively, the smart city evaluation model developed by a team of scientists from Techniche Universität WIEN, Delft University of Technology, and the University of Ljubljana is based on an evaluation of 6 main areas, i.e., "the smart economy, smart people, smart governance, smart mobility, a smart environment, and smart living" (Techniche Universitat WIEN, Delft University of Technology, University of Ljubljana, 2023).

We believe that the importance of a place in the smart city rankings is self-contained at this time and that the potential value of creating smart city rankings is not used when allocating funds. This is also probably because no official and legally recognized smart city evaluation model can be found, where it would be possible to derive a legally recognized entitlement to the allocation of grant funds, or at least, the data of which could serve as one of the criteria for an entitlement to funding from public sources intended for the concept of smart cities.

As can be understood from the Horizon 2020 factsheet, the ability to seek funding and the allocation of funds for the smart cities sector is mostly based on the quality of a city's proposal, the project's feasibility, the projected costs or fullfilling other prescribed criteria, rather than the city's smartness ranking. We are not aware of any direct connection between the overall smart city rankings and the allocation of funds intended for smart cities (European Commission, 2020).

3 MATERIAL AND METHODS

In our analysis we applied data mining methods based on the Community Research and Development Information Service (CORDIS) and Eurostat databases. CORDIS is the European Commission's main public portal and repository for disseminating information on funded EU research projects and their results. CORDIS belongs to the Research and Innovation community platform of the European Commission and complements the Funding and Tender Opportunities website, where one can apply for funding and search for partners (European Commission, CORDIS, 2023).

The Cordis database contains broad datasets, such as those containing past funding programmes (e.g. FP7), data for non-member participating countries, and all kinds of domains driven by EU programmes. Therefore, our data selection had to be narrowed as follows:

- Funded and finished smart city projects
- Horizon 2020 and Horizon Europe
- Full years 2014 - 2022
- 28 EU member countries (but including Great Britain as well until 2022)
- Population data taken from Eurostat (European Commission, Eurostat, 2023)

4 RESULTS

Over the last decade some 319 smart city projects, representing 1.43% of all programme funding, have been financed by the EU Horizon funding programmes. This represents a group of nearly 3400 participants including SMEs, NGOs, academia, public organizations, and other institutions actively involved in smart city research and innovation projects. Fig-

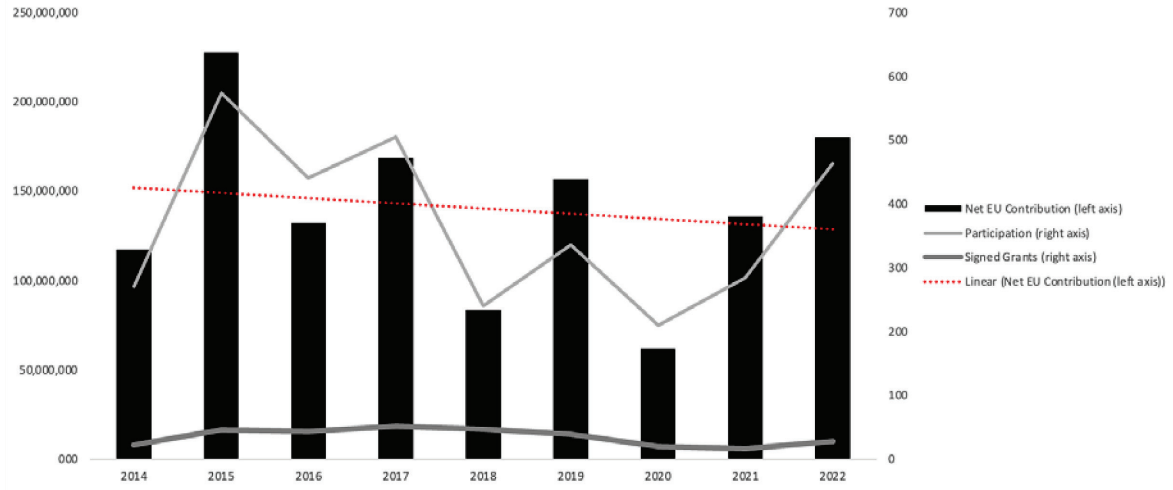


Fig. 2 *EU-funded smart city projects over the last 10 years*

ure 2 shows the distribution of net EU contributions as well as the amount of signed grants for the years 2014-2022 for two programmes, i.e., HORIZON EUROPE and H2020. Their evolution over the last ten years indicates relatively stable EU contributions with a correlating trend for signed grants. The years 2014 – 2021 represent the Horizon 2020 funding period, while 2022 marks the starting year of Horizon Europe. While 2015 was the strongest year in terms of EU smart city project contributions, the Covid-impacted year 2020 had the lowest level of EU funding.

4.1 Overall project success does not equal funding success

It should not come as a surprise that the largest EU economies such as Germany, Spain, the Netherlands, France, and Italy account for more than half (59%) of the Horizon funding awarded in the smart city domain. To put these figures into a broader perspective, we have added a "per capita" view, which changes the country ranking (Figure 3). Leaving all countries but the Netherlands out of the top 5 list and considering the size of funding per capita, Estonia leads the ranking with a solid 22.18 EUR contribution per citizen, followed by Luxembourg (10.81 EUR) and the Netherlands (8.16 EUR). These statistics indicate that large countries have a higher critical mass by imposing stronger penetration in EU projects while consuming a larger portion of the EU funding. From that perspective such countries can be seen as more successful, while underrepresented countries are less successful, since the first group deliver better results at the funding stage of projects and thus receive more funding for smart cities as a whole. In our view, however, it would be beneficial to increase visibility of the overall smart city project outcomes and results, i.e., in their final stage.

To provide a way forward, we decided to link project management perspectives to the rate of success. Instead of evaluating smart city projects as success-based relative to funding consumed (the participant's view), we aimed to analyze success through the optics of delivered project results and outcomes (the sponsor's view). It is important to note, that from a funding perspective, all the projects delivered might be seen as successful, assuming that the project grant has been consumed and maintained by the participants after the project has finished. Nevertheless, we are arguing that despite all 319 projects being funded in the end, the smart city projects analyzed should not be seen as equally successful. In this paper we provide a simplified framework for understanding the differences in success on a ranking scale. In our model, we have considered the following delivered outcomes as project success criteria for 319 smart city projects:

- Amount of intellectual property rights: patents, trademarks
- Number of scientific publications: book chapters, peer reviewed articles
- Number of deliverables: demonstrators' pilots, prototypes, websites
- Amount of project reports: periodic report summaries, etc.

As our model incorporates a project management context, two major success milestones will be analysed: (M1) funding success - a participant's view, and (M2) outcome success – a sponsor's view. A comparison of the M1 and M2 results leads us to the following research questions:

1) What is the level of success when measured in the funding stage of a project?
2) What is the level of success in the outcome stage of a project?
3) Can all SMART CITY PROJECTS funded be considered equally successful?
4) How can the success of SMART CITY PROJECTS be measured?

To provide perspectives to the above research questions, we refer the reader to Tables 1 and 2, which prove that a higher success rate of reaching the SMART CITY PROJECTS´ funding milestone will not correspond to the same success rate of delivered project results. Therefore, all the funded projects cannot be seen as equally successful. Applying the cost of outcomes in our model should help us understand the price EU

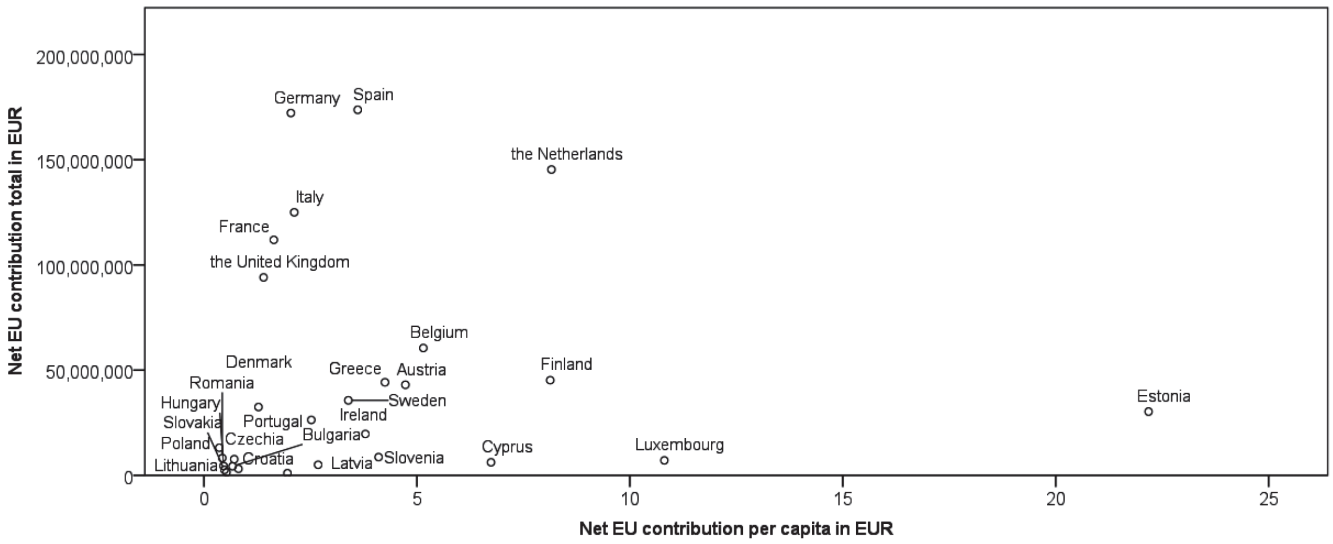


Fig. 3 *Net EU contributions in absolute and relative measures*

taxpayers have to pay for delivered smart city projects. The cost of the outcome has the following formula:

$$Cost\ of\ outcome\ = \frac{ecMaxContribution}{(Patents + Deliverables + Publications)} \quad (1)$$

In that sense, projects with the lowest outcome cost can be seen as more efficient and thus more successful (Table 2).

While Table 1 ranks countries by the amount of SMART CITY PROJECTS funding, sorting the same dataset by the Cost of Outcome (Table 2) changes the ranking significantly, i.e., the leading countries now become Romania, Switzerland, and Norway, while Germany and Spain leave the top 10 list completely. It is interesting to note that low-cost countries do not necessarily top the list.

5 CONCLUSION

Despite the growing importance of smart cities in the context of net zero goals, the net EU contribution in the last ten years has been rather stable, i.e., showing an increase in the recent years of 2021 and 2022. The importance of smart cities, coupled with the relatively low visibility of EU-funded project successes, has motivated us to deepdive into differences among member countries participating in SMART CITY PROJECTS. Even though all the funded projects are deemed more or less successful from a Horizon point of view, it is not clear how they perform after post-funding or how they perform relative to each other. Therefore, we decided to apply project success analyses to help us find subtle differences in terms of project results and their success as such. Currently, the EU Commission reports on project results in a somewhat limited way, such as listing only limited types of results (deliverables, publications, project websites or patents), while leaving the commercial point of view completely out of the equation. Having a higher visibility of the commercial and industrial impacts such as the improvement in the technological readiness level before/after a project, market share, the amount of customers, post-project activity, etc., would probably make the outcomes more transparent to EU taxpayers. We also hypothesize that a higher degree of transparency could lead to more efficient smart city project governance while opening new opportunities for researchers, policymakers, and potential project participants in this domain. Horizon might foster this by delivering more specific success information such as results-oriented project reporting, success KPIs on dedicated Horizon dashboards, and extended datasets.

We have recognized a few limitations in our analysis that require further attention. The first downside is the relatively low availability of commercial and industrial project results.

Tab. 1 *Total contribution by country*

Rank	Country	Projects	ecMaxContribution	Deliverables	Publications	Patents	Cost of outcome
1	Germany	19	105,902,015	409	624	1	102,420
2	Spain	33	86,923,889	348	216	3	153,305
3	France	19	53,488,379	212	297	2	104,674
4	Sweden	10	29,266,015	93	47	0	209,043
5	Lithuania	7	27,549,917	114	231	9	77,825
6	Italy	19	26,476,447	203	222	0	62,298
7	Denmark	3	24,744,149	78	111	0	130,921
8	the United Kingdom	13	15,623,913	138	140	2	55,800
9	Finland	3	12,767,625	100	62	0	78,813
10	Norway	4	10,085,201	116	108	0	45,023

Tab. 2 *Cost of outcome*

Rank	Country	Projects	ecMaxContribution	Deliverables	Publications	Patents	Cost of outcome
1	Romania	2	1,496,610	14	176	2	7,795
2	Switzerland	10	4,585,583	68	59	0	36,107
3	Norway	4	10,085,201	116	108	0	45,023
4	the United Kingdom	13	15,623,913	138	140	2	55,800
5	Luxembourg	2	3,624,795	1	61	0	58,464
6	Italy	19	26,476,447	203	222	0	62,298
7	Belgium	4	8,459,890	63	64	0	66,613
8	the Netherlands	6	10,072,340	52	78	0	77,480
9	Lithuania	7	27,549,917	114	231	9	77,825
10	Finland	3	12,767,625	100	62	0	78,813

Acquiring such data will require in-depth data mining for projects that continue to exist beyond their funding life cycle. The second issue we recognize is the dimension of quality, which should be taken into consideration when talking about results. This could be the impact factor of published articles, the number of citations to publications, etc., to name a few. A further investigation could involve adjusting the cost of outcome indicators to various price levels in EU countries, particularly the costs per person-month. We plan to address these opportunities in a follow-up study with the application of more robust econometric models.

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