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Osvaldo Gervasi · Beniamino Murgante ·
Sanjay Misra · Ana Maria A. C. Rocha ·
Chiara Garau (Eds.)

Computational Science and Its Applications – ICCSA 2022 Workshops

Malaga, Spain, July 4–7, 2022
Proceedings, Part V

5 Part V

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Preface

These six volumes (LNCS 13377–13382) consist of the peer-reviewed papers from the workshops at the 22nd International Conference on Computational Science and Its Applications (ICCSA 2022), which took place during July 4–7, 2022. The peer-reviewed papers of the main conference tracks are published in a separate set consisting of two volumes (LNCS 13375–13376).

This year, we again decided to organize a hybrid conference, with some of the delegates attending in person and others taking part online. Despite the enormous benefits achieved by the intensive vaccination campaigns in many countries, at the crucial moment of organizing the event, there was no certainty about the evolution of COVID-19. Fortunately, more and more researchers were able to attend the event in person, foreshadowing a slow but gradual exit from the pandemic and the limitations that have weighed so heavily on the lives of all citizens over the past three years.

ICCSA 2022 was another successful event in the International Conference on Computational Science and Its Applications (ICCSA) series. Last year, the conference was held as a hybrid event in Cagliari, Italy, and in 2020 it was organized as virtual event, whilst earlier editions took place in Saint Petersburg, Russia (2019), Melbourne, Australia (2018), Trieste, Italy (2017), Beijing, China (2016), Banff, Canada (2015), Guimaraes, Portugal (2014), Ho Chi Minh City, Vietnam (2013), Salvador, Brazil (2012), Santander, Spain (2011), Fukuoka, Japan (2010), Suwon, South Korea (2009), Perugia, Italy (2008), Kuala Lumpur, Malaysia (2007), Glasgow, UK (2006), Singapore (2005), Assisi, Italy (2004), Montreal, Canada (2003), and (as ICCS) Amsterdam, The Netherlands (2002) and San Francisco, USA (2001).

Computational science is the main pillar of most of the present research, and industrial and commercial applications, and plays a unique role in exploiting ICT innovative technologies. The ICCSA conference series provides a venue to researchers and industry practitioners to discuss new ideas, to share complex problems and their solutions, and to shape new trends in computational science.

Apart from the 52 workshops, ICCSA 2022 also included six main tracks on topics ranging from computational science technologies and application in many fields to specific areas of computational sciences, such as software engineering, security, machine learning and artificial intelligence, and blockchain technologies. For the 52 workshops we have accepted 285 papers. For the main conference tracks we accepted 57 papers and 24 short papers out of 279 submissions (an acceptance rate of 29%). We would like to express our appreciation to the Workshops chairs and co-chairs for their hard work and dedication.

The success of the ICCSA conference series in general, and of ICCSA 2022 in particular, vitally depends on the support of many people: authors, presenters, participants, keynote speakers, workshop chairs, session chairs, organizing committee members, student volunteers, Program Committee members, advisory committee members, international liaison chairs, reviewers, and others in various roles. We take this opportunity to wholehartedly thank them all.

We also wish to thank our publisher, Springer, for their acceptance to publish the proceedings, for sponsoring some of the best papers awards, and for their kind assistance and cooperation during the editing process.

We cordially invite you to visit the ICCSA website https://iccsa.org where you can find all the relevant information about this interesting and exciting event.

July 2022

Osvaldo Gervasi
Beniamino Murgante
Sanjay Misra

Welcome Message from Organizers

The ICCSA 2021 conference in the Mediterranean city of Cagliari provided us with inspiration to offer the ICCSA 2022 conference in the Mediterranean city of Málaga, Spain. The additional considerations due to the COVID-19 pandemic, which necessitated a hybrid conference, also stimulated the idea to use the School of Informatics of the University of Málaga. It has an open structure where we could take lunch and coffee outdoors and the lecture halls have open windows on two sides providing optimal conditions for meeting more safely.

The school is connected to the center of the old town via a metro system, for which we offered cards to the participants. This provided the opportunity to stay in lodgings in the old town close to the beach because, at the end of the day, that is the place to be to exchange ideas with your fellow scientists. The social program allowed us to enjoy the history of Malaga from its founding by the Phoenicians...

In order to provoke as much scientific interaction as possible we organized online sessions that could easily be followed by all participants from their own devices. We tried to ensure that participants from Asia could participate in morning sessions and those from the Americas in evening sessions. On-site sessions could be followed and debated on-site and discussed online using a chat system. To realize this, we relied on the developed technological infrastructure based on open source software, with the addition of streaming channels on YouTube. The implementation of the software infrastructure and the technical coordination of the volunteers were carried out by Damiano Perri and Marco Simonetti. Nine student volunteers from the universities of Málaga, Minho, Almeria, and Helsinki provided technical support and ensured smooth interaction during the conference.

A big thank you goes to all of the participants willing to exchange their ideas during their daytime. Participants of ICCSA 2022 came from 58 countries scattered over many time zones of the globe. Very interesting keynote talks were provided by well-known international scientists who provided us with more ideas to reflect upon, and we are grateful for their insights.

Eligius M. T. Hendrix

Organization

ICCSA 2022 was organized by the University of Malaga (Spain), the University of Perugia (Italy), the University of Cagliari (Italy), the University of Basilicata (Italy), Monash University (Australia), Kyushu Sangyo University (Japan), and the University of Minho, (Portugal).

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Contents – Part V

14th International Symposium on Software Engineering Processes and Applications (SEPA 2022)

The Cost-Benefit Analysis for the Validation of Next Generation EU Investments: An Application to the Healthcare Sector

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Abstract. During the last decades, the public investments have very often determined "white elephants" whose initial costs have increased during construction phase and, at the end of project realization, the necessary financial resources for the operation of the investment have not been available. Starting from these bankruptcy initiatives, different technique for an accurate ex ante planning of the investment costs, and for a detailed analysis of the financial sustainability have been implemented. The Cost-Benefit Analysis is the most used tool for the public investments validation as it is able to verify the financial intervention convenience, and it allows an optimal allocation of available resources in order to guarantee the highest return on investment in the reference area. In this research, the Cost-Benefit Analysis potential and limits have been highlighted through a specific case study.

Keywords: Cost-benefit analysis · Health care sector · NRRP · Willingness to pay · Value of statistical life

1 Introduction

The selection of high quality projects able to meet the changing needs of the community and to determine significant effects on economic growth is a fundamental operation in the definition of urban development strategies. In this context, the Cost-Benefit Analysis (CBA) assumes a key role, being expressly requested for the evaluation of interventions aimed at obtaining co-financing for the "large public projects" – i.e. characterized by a total investment cost higher than € 50 million - included in the operational programs of the European Regional Development Fund (ERDF) and the Cohesion Fund [9, 37].

In general terms, the CBA intends to verify the initiative convenience for the community deriving from the project implementation, in order to orient the urban policies towards an efficient allocation of financial resources. In this way, this analysis constitutes a significant support in the decision-making process for the choice of the investments

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to be carried out [18, 36] taking into account the sustainable territorial development strategies and the priority objectives set by the European Union.

With reference to the Next Generation EU (NGEU) [32], aimed at promoting a "sustainable, uniform, inclusive and equitable recovery" following the crisis caused by the Covid-19 pandemic, in Italy the National Recovery and Resilience Plan (NRRP) [31, 38] establishes an accelerated procedure for the construction of public works on the basis of the technical and economic feasibility project, in order to streamline the bureaucratic procedures related to the design, approval and implementation phases.

The amount of the allocated funds and the timing foreseen for their use of the Resilience and Recovery Facility (period 2021–2026) [10], on the one hand, generate the need to simplify the procedures to speed up the works construction times and, on the other hand, require choices capable of guaranteeing high quality standards of interventions.

In this sense, the NRRP promotes an innovative approach towards the design, construction and management of a public work, paying significant attention to environmental and sustainability goals and, at the same time, making the approval process more efficient through targeted simplification tools. In the context of the guidelines for the drafting of the technical and economic feasibility project to be put out to the awarding of public works contracts of the NRRP and of the National Plan for Complementary Investments (NPC), developed by the Superior Council of Public Works [6], the CBA is recognized as the main methodological tool to support the selection among design alternatives that pursue the preliminary fixed objectives. The document also highlights that, while allowing for the initial use of more "rapid" techniques (multi-criteria analysis [17, 29] and cost-effectiveness analysis), the results obtained must be validated by a CBA, in order to clearly and objectively identify the "best" project solution.

Furthermore, the guidelines recommend a constant monitoring and updating of the data included in the CBA developed for the definition of the selected solution, in accordance with the precise identification of the constructive and functional typologies and a more accurate estimate of the overall intervention costs.

In the mentioned framework, the CBA plays a central role *i)* for forecasting the effects of the project (ex ante analysis), *ii)* for monitoring the evolution of the boundary conditions (in itinere analysis), *iii)* for checking the pursuit of the assessed outputs (ex post analysis).

Within the framework of the structural reforms and investments for the period 2021–2026 envisaged by the NRRP, among the six priority intervention sectors described in the plan, the Mission 6 concerns the health and resilience issue, with the aim of strengthening prevention and health services on territory, of modernizing and digitizing the healthcare system and of guaranteeing equity in access to care. In particular, € 16.63 billion have been allocated for this Mission, i.e. 8.16% of the total amount of € 191.5 billion relating to the Recovery and Resilience Facility (RRF – the main component of NGEU program) to be used through the NRRP implementation. The measure resources are distributed with different shares in two investment lines relating to: *i)* proximity networks, intermediate structures and telemedicine for territorial health care - whose main objectives concern the improvement of the services provided in the territory thanks to the strengthening and creation of territorial facilities (such as Community Homes and Community Hospitals), the consolidation of home care, the development of telemedicals and a more effective integration with all social and health services; *ii)* innovation, research and digitization of the National Health Service - aimed at the renewal and modernization of existing technological and digital structures, at the completion and dissemination of the electronic health record, at a better performance of delivery and monitoring of the essential levels of assistance through more effective information systems.

In general terms, the emergency caused by Covid-19 pandemic has pointed out the need to improve the National Health System (NHS) capacity to provide adequate services, not only to strengthen and reorganize the supplied services, upgrading their quality levels, but also to modernize the technological and digital hospital devices, currently characterized by a significant obsolescence state and frequently lacking in many facilities, also in terms of structural adaptation and safety of hospital buildings.

The present research is part of the framework outlined and it is focuses on the implementation of a CBA on a healthcare building project to be realized through NRRP funds in a city located in Southern Italy. By analyzing the financial and economic effects determined by the intervention with reference to the territorial context and the current temporal horizon, the presented application of the CBA can constitute a vademecum for similar projects: in this sense, the work could effectively support public and private subjects involved in these typologies of investments.

2 Case study

In Italy, the progressive ageing population, the decline in the fertility rate, the negative birth-rate [21] and the consequent increase in the economic and social burden linked to age-related diseases, define the typical framework of the “demographic trap”.

This condition could determine extremely relevant effects derived from the impossibility to support the economic weight of assistance with the working population incomes. For this reason, the prevention of pathological aging and the consequent increase in healthy life expectancy are among the fundamental modifiers of the impact of the growth in the socio-economic burden of demographic transition.

Therefore, the case study analysed in the present research concerns the realization of a healthcare building called “Health House 2.0” which aims to overcome the classic idea hospital care, through three different complementary action lines: *i)* optimization of healthcare services; *ii)* creation of a Research, Development and Innovation (RDI) infrastructure; *iii)* the prevention culture spread.

In the following sections, the steps of the CBA - mandatory for the fund request of € 12 million in the context of the NRRP - for the construction of the “Health House 2.0” in a specific area (named “reference area”) of the Apulia region in Southern Italy. This fund is required for the property enhancement and the supply and installation of a series of hospital equipment. The project is proposed by a scientific hospitalization institute (the “promoter”) and it provides for the involvement of different public partners (universities, local and common healthcare companies) and private ones (companies interested in developing patents).

2.1 Definition of the Intervention Goals

The "Health House 2.0" represents a strategic infrastructure for research, development and innovation:

- to enhance and improve the research activities carried out within the national health system;
- to contribute to the development of the technical, professional, digital and managerial skills of the health system staff;
- to promote the knowledge progress concerning the aging, fragility and functional decline issue, by introducing an infrastructure capable of processing and integrating primary and secondary big data;
- to develop advanced innovative processes and services, such as semi-residential structures for assisted rehabilitation and cognitive-behavioral and physical tele-rehabilitation;
- to strengthen collaboration among research, innovation, education and the business sector in order to generate more employment.

The achievement of mentioned goals translates into the need to implement initiatives aimed at reducing the gap between the national average and the regional data, associated with a series of indicators listed below [20]:

- incidence of total RDI expenditure on GDP (1.47% Italy vs. 0.82% Apulia - 2019);
- RDI employees, units expressed in full-time equivalents per thousand inhabitants (5.96 Italy vs, 2.77 Apulia - 2019);
- companies that have carried out RDI activities in collaboration with external parties out of the total number of companies that perform RDI (0.59% Italy vs. 0.35% Apulia);
- production specialization in high-tech sectors described as the percentage of employees in high-tech manufacturing, knowledge-intensive and high-tech services sectors on the total employment (3.85% Italy vs. 2, 18% Apulia - 2020);
- percentage of elderly people assisted at home compared to the population age at least 65 years old (0.90% Italy vs. 0.60% Apulia);
- percentage of inappropriate hospitalizations in terms of admissions with a high risk of inadequacy beyond 1 day on the total resident population (0.58% Italy vs. 0.65% Apulia for Diagnosis Related Groups (DRG) doctors, 0.29% Italy vs. 0.36% Apulia for DRG - 2019).

2.2 Demand Analysis

Starting from the multiple intervention goals, the demand is articulated on several points of view, summarized below according to the target group:

- *enterprises*: knowledge intensity in the sectors connected to the project, development of new products and participation in the creation of start-ups;
- *researchers, students* and *academics*: increase and diversification of training activities, incentive for public and private investments, creation of partnerships with production companies;

– *population*: increase in the life quality through easier and more targeted access to health services, reduction of the digital divide and social inequalities.

With reference to the *enterprises*, the large team involved in the project and the important equity commitment in terms of newly recruited staff to be paid by the companies (to be allocated to the intervention development), confirm the interest aroused in the regional production system. This empirical observation is validated by the current growth both in the number of researchers employed in RDI activities in collaboration with external parties, and in the companies that have carried out RDI activities using research infrastructures and other RDI services. The described trend effectively represents the current demand from the production sector which plays an increasingly central role in promoting research and its applications.

With regard to the second target group (*researchers*, *students* and *academics*), it should be observed that, despite the low investments in RDI at national and regional level, human capital has grown, supported by the increase in RDI employees and by the Apulian academic system, for which starting from the A.Y. 2016–2017, a constant growth of enrolled students has been recorded. This condition highlights the good scientific level of the local university system and a growing demand for RDI staff.

For the last target group (*population*), a higher difficulty to univocally characterize the demand in terms of load reduction of the fragilty single macro-domains, especially cognitive disorders, functional and lifestyle disability [2] - with particular reference to nutritional balance and dietary habits [41] – has been detected. The "proxy" variables used to characterize this demand are: *i)* the number of elderly people assisted at home; *ii)* the number of high risk inappropriateness hospitalizations.

The combination of these strategies contributes to the implementation of the previously illustrated goals. Compared to the reference area, the number of elderly people to whom home care could be extended is equal to a minimum of 59, if the national average is taken as a referred, to a maximum of 767, if the Bolzano province (the most "performing" area in the Italian context) is considered. However, the subsequent analysis refers to the patients number currently assisted at home (equal to 150 units), in order to consider a prudential scenario for challenging goals. In addition, it should be recalled that the NRRP also aims to promote innovative solutions and instrumental endowments for elderly people to guarantee them an autonomous and independent life and home social assistance services.

In order to define the demand, in terms of reduction in hospitalizations, the "best scenario", that is the shelters number to be prevented at 4 years following the operativity start, has been determined by using two methodologies: the first "bottom up" has concerned the involvement of the local healthcare Entity to specify, for each potentially inappropriate DRG, the number of avoidable hospitalizations; the second "top down" has identified this number as the difference (weighted with respect to the reference area) of the gap existing between the most performing region, i.e. Piedmont, and the Apulia region. The bottom up approach has led to the need to reduce the hospitalizations number by 389 units, the top down approach by 413 units. Prudently, the goal to be achieved implementing the bottom up approach has been selected.

2.3 Options Analysis

The options analysis has been carried out with the support of multi-objective techniques, that are characterized by a high performance in particularly uncertainty contexts; at the end of the analysis, a ranking of the alternative solutions identified by means of a summary numerical indicator has been obtained.

The general goal, previously described, has been divided into four macro-objectives (A, B, C and D) to which a weight (w) has been assigned by the partners involved in relation to the importance compared to the general objective achievement.

A. ($w = 35\%$): to upgrade research quality and products, also increasing the number of graduates connected to smart specialization;
B. ($w = 30\%$): to strengthen collaboration among research, innovation, education and the business sector in order to create new jobs;
C. ($w = 20\%$): to generate a more resilient, inclusive and democratic society, by contributing to greater "Digital Equity" and "Gender Equality";
D. ($w = 15\%$): to improve the life quality of the general population and, in particular, of the elderly one, through a renovation in the social welfare assistance supply.

For each of the four macro-objectives, three options have been identified that differ, depending on the situation, in strategic, technological or location aspects; moreover, an evaluation matrix to identify how the different options pursue the objectives achievement, has been built. For the implementation of this step, the identification of a criteria set (costs, times, revenues, etc.) - each with a different weight, established through the partners involved support - has been developed. For each criterion, a verbal judgment or a general numerical indication - subsequently normalized and included in the 0–1 scale using the MIN-MAX normalizer – has been assigned. Finally, three solutions have been defined and shown in Fig. 1: I. Health House, II. Consortium exclusively composed by regional entities; III. Pool of only public subjects. For these intervention alternatives, a synthetic indicator obtained through the classical aggregative approach of Weighted Sum Model has been calculated. The project one "I" is the preferred solution (synthesis value equal to 0.78) followed by "II" (synthesis value 0.57) and, finally, "III" (synthesis value 0.48). In particular, the solution "I" is more performing compared to the other ones for all objectives except for "C" goal. In the following paragraphs, the analysis is focused on the preferred solution, i.e. on the "Health House 2.0".

2.4 Financial Analysis

For the financial analysis, only incoming and outgoing cash flows have been considered (therefore no amortization or provisions have been included in the analysis) at constant real prices. The VAT has been taken into account as it cannot be recovered by the project promoter. It should be specified that the cash flows have been estimated by using an incremental approach compared to the counterfactual scenario, i.e. that related to the non-realization of the planned project (so-called Business As Usual or "as is" scenario).

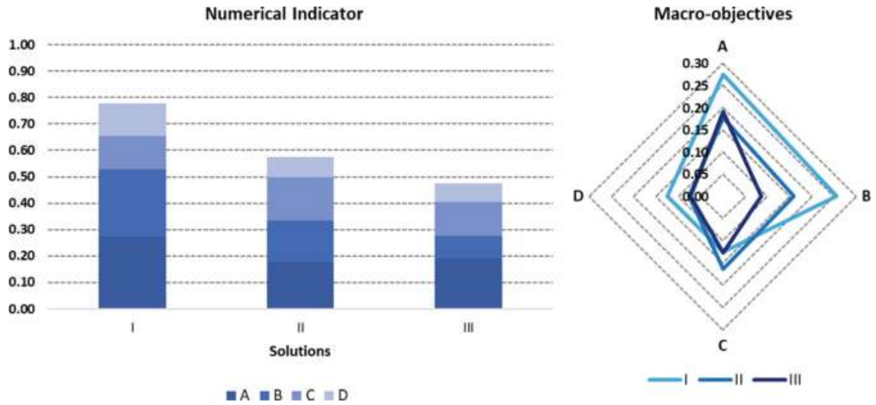

Fig. 1. Outputs obtained by the options analysis

The evaluation data is referred to 06/30/2022, i.e. the presumed date of the fund reception. The analysis has been performed with periods equal to one year, with the exception of the first period considered equal to six months. This differentiation has been explained by indicating that the first semester expenses have been measured in a sufficiently detailed way and correspond to different costs already incurred by the promoter for participating in the procedure. For the subsequent periods the analysis on an annual basis has been developed, as there are not enough elements for a shorter periodization.

The financial analysis has been implemented in the following phases: i. Estimation of the Financial Discount Rate; ii. Calculation of the operating costs; iii. Calculation of the revenues; iv. Analysis of the financial profitability and sustainability.

Phase I: Estimation of the Financial Discount Rate

The project concerns the research and innovation sector, for which the Guide to CBA [9] suggest a time horizon equal to 15–25 years, and the health services context, for which the reference period is set equal to 30 years. Therefore, starting from the previous analysis, a reference period of 29.5 years has been assumed.

The costs and revenues have been actualized using the Financial Discount Rate (FDR) determined by means of the Weighted Average Cost of Capital (WACC): the FDR (equal to the WACC) is the weighted average of the cost of equity (k_E) and debt (k_D) (which corresponds to the public financing in the present case). The WACC mathematic formula is shown in (1):

$$WACC = k_E \cdot E + k_D \cdot D \tag{1}$$

The partners involved in the initiative contribute to the project through an equity commitment connected with the employment of personnel (so-called “contribution in kind”) for an amount of approximately € 4.6 million in the first 4.5 project years (E = 19%), whereas the public funds in the same period amounted to a total of € 20 million (D = 81%). The Capital Asset Pricing Model (CAPM) has been applied to estimate k_E, identifying the European $\beta_{HI\&T}$ for the Heathcare Information and Technology (HI&T)

sector published by Prof. Damodaran, the market risk (R_m) equal to Return On Equity (ROE) of the HI&T sector and the risk free R_f equal to the gross yield of the 30-year BTPs on 01/05/2022. The k_E has been assessed through the formula (2):

$$k_E = R_f + \beta_{HI\&T}\left(R_m - R_f\right) \tag{2}$$

The k_D calculation has been carried out by considering the sum of the EURIRS yield at 30 years (03/11/2022) and the adjusted default spread for Italy. The application of this procedure has determined an FDR equal to 4.86%, higher than the rate recommended by the Guide to CBA (equal to 4%) [9].

Phase II: Calculation of the Operating Costs

The investment costs amounted to a total of € 12 million and have been divided into professional costs, construction costs, equipment and VAT. The professional costs will largely occur in the first semester of analysis, whereas the construction costs will arise in 2023 and 2024 and the costs related to the equipment installation will be incurred in 2024. Within the investment costs, theoretically, the value of the property to be transformed should be included, also because it represents a physical asset held by the promoter and by the various project partners, for which a return could be expected as for any other form of (differentiated) invested capital.

However, a reference market of the property has not been detected and is bound to its current intended use; moreover, the cash flows have been determined using the incremental approach, so in the current scenario ("as is") the property performs functions similar to those covered downstream of the enhancement project. For these reasons, the value at year zero has not been considered; to balance this assumption, when determining the residual value, the contribution deriving from the real estate component has been taking into account exclusively in terms of the increase in value associated with its valuation.

Almost all costs of Operation & Maintenance (O&M) will occur starting from 2025 (i.e. at the end of equipment the installation) with the exception of the costs associated with promotional campaigns, training courses that will take place starting from 2024 (year of completion of the building enhancement works).

The equipment maintenance costs have been estimated on the basis of the management contract currently in place between the promoter and a company specializing in the management and maintenance of equipment similar to those of the present project.

The incremental costs of medical and nursing staff employed for the reduction of inappropriate hospitalizations and increase of services are equal to 60% of the corresponding estimated revenues starting from the rates of hospital assistance services. This percentage, proposed by Formez PA (Center for services, assistance, studies and training for the P.A. modernization) [14], considers the fixed management costs (firstly personnel) that are not compressible and associated with each service.

The property management, operation and maintenance costs have been calculated according to the research contribution developed by the Institute of Economic and Social Research (IRES) of Piedmont in 2018 [35], such as (3):

$$p_a = I \cdot \left(\frac{\beta - 1}{\alpha \cdot Vu}\right) \tag{3}$$

where I is the real estate investment cost, β is a weighting coefficient between useful and operating life with or without maintenance (equal to 3.0), α is the weighting parameter of the useful life to the operating life (equal to 0.8) and Vu is the useful life (equal to 90 years).

To determine the costs associated with the disposal of the abandoned site at the end of the infrastructure life cycle (T), the corresponding parametric value (p) provided by the "Building typology prices" list [4], has been applied to the Gross Building Area (S). Finally, this value has been discounted from the year in which the intervention should be carried out (i.e. in 2113 at the end of the useful life of the property) to the last analysis period (i.e. 2051) through the FDR:

$$T = \frac{p \cdot S}{(1 + FDR)^{62}} \tag{4}$$

The costs to be incurred every 10 years for equipment the replacement is equal to the price incurred at the start of the project, due to the assumption adopted in the analysis for which this is carried out considered real and constant prices.

Phase III: Calculation of the Revenues

The project revenues will start from 2025 through a gradual trend (40% in the 1st year, 60% in the 2nd year, 80% in the 3rd year and 100% from the 4th year), necessary to consider the progressive full implementation of the initiative and the operativity of all aspects. This hypothesis is particularly prudential, especially for revenues related to the health infrastructure that will meet an already existing demand and unsatisfied from the current supply.

Revenues deriving from the consulting services sale and the fees paid for accessing to the laboratories and for the research equipment use have been determined in consultation with the project partners. The reference tariff for the calculation of research services will be assessed with reference to equivalent European centers. In particular, the model proposed by the Center of Advanced Neuro-sciences of the Aalto University in Finland will be taken as a reference: the hourly rate depends on the agreement with the scientific consortium or if the user is a consortium partner. For example, for the use of Nuclear Magnetic Resonance at 3T for the weekdays from 9 to 16, standard rates will be applied that include technical support and auxiliary personnel with the following hourly rates: weekdays € 285 and € 210 for each "off hour" for subjects with a specific agreement, whereas € 427 and € 299 per hour for non-affiliated external parties [1].

Revenues from licenses obtained from the patents marketing have been determined by estimating the costs incurred (or of reproduction): this assumption has led to revenues equal to € 675,000 per patent, in line with the results of the studies carried out by the European Commission [11, 12].

The project intends to activate several masters for a total of 80 students per year (20 places in Public Health, 20 places in Health Data Science, 40 Nutritional Epidemio-logy) and two fellowships for PhDs that will guarantee incomes from the registration fees for a total of € 205,000 per year (2,500 euros for each student).

One of the benefits expected from the project implementation concerns the improvement of health services through three complementary strategies:

- the reduction of 389 inappropriate hospitalizations and emergency department visits in code white (low priority);
- the increase of 4,800 specialist services in one year;
- the activation of remote monitoring services for 150 patients currently assisted at home.

For the reduction of inappropriate hospitalizations, in relation to the year 2021, for the hospitals located in the reference area, the number of accesses to the 43 DRGs with high risk of non-appropriateness in ordinary hospitalization has been analyzed, as defined in the annex 2C of the D.P.C.M. November 29, 2001 [8], and further 55 DRG identified as part of the study carried out by the Ministry of Health [27] have been added.

Within the context outlined, only the DRGs currently provided in the hospitals located in the reference area have been selected. Starting from the data developed by the National Healthcare Institute (partner of the project) for each DRG, an expected reduction in access to 4 years from the intervention completion for a variable percentage from 25 to 60% depending on the specific DRG analyzed, has been assumed, i.e. an equivalent number of missed visits equal to 389 units.

This method represents a prudential approach when compared with the strategies proposed by Formez PA in the context of cost/benefit analyzes of various Health House located in Southern Italy regions [14–16], according to which a reduction equal to 85% in these visits within 4 years from the start of the project has been provided. The corresponding revenues in the "full operatively" period have been assessed by taking into account the expected visits reduction, as already defined, and the fees of acute hospital care services (DRG system) and they are equal to € 386,600 per year.

The increase in diagnostic equipment will allow a growth of at least 20 visits per day which will correspond to an increase in revenues from tariffs of approximately € 3.2 million per year. Currently about 150 patients are assisted at home, and the annual cost for NHS is equal to 4,275 euros/patient, assuming at least 1 weekly visit carried out by a team of 1 medical and 2 nurses within a radius of 15 km for not particularly complex situations. Furthermore, the activation of remote sensing services will determine a lower cost of at least 20%.

The fees paid for the new services envisaged are considered as project revenues in order to assess the financial profitability, as they are incurred for additional services and increases in health services currently provided.

Since the economic life of the initiative works will not completely exhausted at the last year of the time horizon considered, the calculation of the investment residual value has been carried out. This value has been assessed as the sum of two components, that are *a)* the operational component, linked to the residual value of the machinery and to their performance, and *b)* the real estate component connected to the building enhancement investment. With reference to the component *a)*, it should be observed that the hypothesis concerns the machinery replacement since 3 years after the last year of the time horizon (assuming the replacement every 10 years). Therefore the operational component residual value has been determined by anticipating the associated net cash flows at the last year of the time horizon. The residual value (RV) associated with the real estate valuation has been assessed using the formula (5):

$$RV = (1 - D) \cdot I \tag{5}$$

where I is the reconstruction cost equated to the initial investment cost and D is the depreciation coefficient, proposed by the European Union of Accounting Experts [23], determined by applying the mathematical relation (6):

$$D = \frac{\left(\frac{n}{Vu} \cdot 100 + 20\right)^2}{140} - 2{,}86 \tag{6}$$

where n is the building age in years and Vu is the building useful life in efficiency (considered equal to 90 years).

In overall terms, the residual value is approximately equal to € 6.8 million, of which € 3 million are related to the operating component and € 3.8 million concern the real estate one.

The project provides for a total public funding of € 20 million of which € 12 million are requested in the context of NRRP (which cover the costs for the development of the property and the equipment purchase) and € 8 million are related to national or regional funds previously allocated for the Health House to be used for ordinary activities (maintenance, training, etc.).

Phase IV: Analysis of the Financial Profitability and Sustainability

According to the indications included in the Community Guidelines, the Financial Net Present Value (FNPV) and the corresponding Financial Rate of Return (FRR) have been determined both with respect to the investment in general (FNPV(C) and FRR (C)) – i.e. not considering the specific financing sources - and to the national capital (FNPV(K) and FRR(K)) – i.e. including the financing requested with a negative sign. The results show that the initiative is financially profitable and there are no substantial differences in the profitability of the investment with respect to the two points of view, as the two situations differ exclusively for a different distribution of costs in the early years. In fact, by analyzing the investment in general terms, in the early years there are the cash outflows necessary for the enhancement of the property and the equipment purchase, whereas, by considering the national capital, in the first years the "costs" concern the loans used to cover the investment costs.

The FNPV(C) of the investment is equal to over € 2.9 million which correspond to a FRR(C) equal to 6.7%, higher than the FDR; the FNPV(K) of the national capital is equal to approximately € 2.7 million and the associated FRR(K) is 6.4%.

Despite the good financial performance, the project needs the required public financing as the initiative is not bankable and, therefore, it cannot independently start if not adequately supported.

The project outputs attests the financial sustainability, as the cumulative cash is always greater than zero value and there are not years characterized by cash tensions. This result is strongly influenced by the revenues from the new services performed and by the lower costs incurred thanks to the decrease in improper visits. The optimization of the cash flows by reducing the deficit has not been carried out in order to deal with any critical situations.

2.5 Economic Analysis

The economic analysis has been carried out according to the following steps: *i*. Calculation of the Social Discount Rate; *ii*. Determination and application of the Conversion Factors; *iii*. Evaluation of externalities; *iv*. Estimation of benefits; *v*. Analysis of the economic performance.

Phase I: Calculation of the Social Discount Rate

For the estimation of the Social Discount Rate (SDR), the Community Guidelines suggest a variable reference value between 3% and 5%, from which the variation could be performed through the alternative application of two approaches: the first one is based on the determination of the Social Rate of Return on Private Investments (SRRI) and it consists in considering the return on public investment equal to that obtainable with a private investment without the risk premium, whereas the second one concerns the identification of the Social Rate of Time Preference (SRTP) equivalent to a government bond. In the present project assessment, regardless of the specific approach considered, the same result has been achieved, i.e. the SRRI is equal to the SRTP that is equal to the gross yield of the 30-year BTPs detected on 01/05/2022. By taking into account that this value is lower than 5% recommended by the Community Guidelines for this loan request, as a prudential SDR equal to 5% has been selected.

Phase II: Determination and Application of the Conversion Factors

The costs considered in the economic analysis are those determined in the financial analysis multiplied by the Conversion Factors (CFs). In order to assess the CFs able to pass from the market prices, used in the financial analysis, to the shadow prices, to be applied in the economic analysis, the standard CFs proposed by two official sources [33, 39] have been used. In general, the UVAL has been preferred, as the proposed CFs are differentiated by investment typology and are more recent.

For the determination of the CF to be applied to the costs of healthcare personnel for the transformation from market wages to shadow ones, a relevant modification compared to the values proposed by UVAL and NUVV has been carried out, as they concern the labor. Moreover, the CF to be applied to the costs of healthcare personnel has been determined as the average of the CFs associated with the various profiles, indirectly calculated by applying the following formula (7):

$$CF = (1 - i) \cdot (1 - d) \tag{7}$$

where i is the income tax, i.e. the average IRPEF rate that varies according to salary and, therefore, the specific job position, and d is the unemployment rate of the year 2020 provided by ISTAT for the Southern Italy (differentiated by qualification). The CF of healthcare personnel is higher than labor one, due to the lower unemployment associated with these professional profiles.

Phase III: Evaluation of Externalities

The project generates negative environmental externalities, related to the emission of greenhouse gases.

To estimate the corresponding monetary effects, the equivalent tons of CO_2 generated by investments in construction and machinery, labor and overheads have been firstly determined (applying factors provided by UVAL); subsequently the tons of CO_2 activated have been multiplied by the corresponding unit value (equal to 37 Euro/t-CO_2e) identified by applying the EIB's "Carbon dioxide footprint methodology" [13].

Phase IV: Estimation of Benefits

In general terms, the project involves many regional and national companies, already included in the structuring phase as project partners. Their main benefits concern the incremental shadow profit compared to the "as is" scenario, i.e. the no project situation. The assessment of the increase in profits, and its subsequent correction to take into account market distortions, has been developed starting from the financial analysis revenues, such as the sale of consultancy services, the revenues obtained from the patents marketing and the tariffs for access to laboratories and for the use of research equipment. To these benefits the contribution in kind has been added, i.e. given by the companies involved in terms of personnel included in the project: this approach implicitly considers that the increase in profit will certainly be higher than the investment carried out by companies. Moreover, the approach used is precautionary, as it does not take into account all the benefits associated with the new products development and the existing processes improvement, by avoiding the risk of double counting of the benefits.

The training and research activity plays a central role in the project: in fact, it is planned to activate several masters for a total of 80 students per year (20 units in Public Health, 20 in Health Data Science, 40 Nutritional Epidemiology) and various doctoral schools for a total of 12 doctoral students per year, 10 units of which are directly funded by companies as an equity commitment. In addition, the project focuses on the structuring of data in the health sector and on its systematic management for the benefits of the new knowledge production and its dissemination through scientific publications. The connected unitary benefits can be represented by the marginal social value of scientific publications estimated as the ratio between the gross remuneration of the personnel employed in research activities and the number of publications developed. The researchers involved are mostly PhD students, whose gross annual remuneration is around € 20,000. For the identification of the number of publications potentially carried out in a year by an ordinary PhD student, the threshold value in terms of articles number in 5 years to be presented as a requirement for the National Scientific Qualification for 2nd level Professor has been considered [25] (in relation to the Scientific Disciplinary Sectors interested in the project). Starting from this average value (2.29 publications/year), the value of a publication for an ordinary PhD student has been identified, equal to € 8,750/publication. To apply this value to the project specifications, it has been considered that: i) the researchers employed will also carry out other complementary academic activities for about 10% of their time and ii) the project infrastructure will improve the performance compared to an average researcher, of about 20% in terms of increase in publications. Finally, the benefits per researcher are equal to € 21,600/year which corresponds to an overall benefit of € 259,000/year when fully operational. The approach implemented is precautionary as it does not consider the additional effect resulting from the citations and the consequent increase in the indicators associated with the researcher scientific activity.

In addition to the benefits in scientific publication terms, the positive effect for young researchers and students involved in the project concerned the acquired skills that help in future job collocations, by increasing career prospects has been analyzed. The "proxy" variable used to estimate this benefit is the incremental remuneration for the benefits of PhDs and master's graduates, compared to a "normal" graduate. According to the 2021 reports "Employment condition of research doctors" and "Employment condition of master's graduates" carried out by the AlmaLaurea Interuniversity Consortium [7], the employment rate of PhDs one year after graduation is 88.1%, of master's graduates 86.9%, whereas the second level graduates reach an employment rate of 87.7% 5 years after degree obtainment. Also on the remuneration point of view, the differences are significant: the master's graduate has an average monthly net remuneration equal to € 1,745, the PhD to € 1,728 and the "normal" graduate to € 1,364. The overall benefits, when fully operational, associated with these increases are approximately equal to € 450,000/year. To avoid double counting of these benefits typologies, the fees associated with masters and PhD courses have not been included in the economic analysis. As previously described, the project intends to realize various interventions aimed at reducing mortality and morbidity rates and improving health conditions of the population living in the reference area. These objectives are implemented through a) the reduction of 389 inappropriate hospitalizations and the access to the emergency department visits in code white (low priority), b) an increase of 4,800 specialist services in one year, c) the activation of remote monitoring services for 150 patients currently assisted at home.

The benefits associated with the reduction of 389 accesses have been measured through the monetary amount that the patients would be willing to pay to avoid going to hospital facilities. In this sense, for the benefit monetary quantification, i.e. the Willingness To Pay (WTP), the study developed by Pearce D. [34] has been borrowed. In particular, the analysis has identified the corresponding European average WTP in 2000 at € 490/missed situation, that, revalued in 2022 by means of the consumer price index for families of workers and employees developed by ISTAT [19], is equivalent to € 702/missed situation. This amount implicitly incorporates the costs for avoided mobility and it should be noted that there will be no improvements in terms of increased life expectancy or life quality for the 389 missed accesses, as these patients would have gone to hospital facilities, by obtaining a performance benefit (in terms of decreased mortality and morbidity) similar to that obtained through the project's initiatives. Moreover, it should be pointed out that the corresponding benefits, equal to over 270,000 euros/year, are 80% higher than the financial savings obtained (equal to over 150,000 euros / year).

Furthermore, it is assumed that the 4,800 additional benefits expected to be provided in one year will cause a decrease equal to 25% in the death risk in 10 years, a drop equal to 12.5% of morbidity risk [3] and an increase in quality of life equal to 15 points (measured with surveys based on SF-36 interrupted series analysis on the population living in the intervention area, which will be proposed after the activation of the structure). To estimate the related benefits, the Value of Statistical Life (VSL) has been identified starting from the publication of Miller T.R. [24]. The VSL is equal to approximately € 3.2 million (recalculated in 2022 with respect to the GDP per capita), lower than the approximately € 6.4 million estimated by Viscusi W.K. in 2021 [40] (based on the WTP). As a precaution, the lower amount has been considered. Finally, since these interventions will concern the population over 64 years old, the probability of corresponding mortality has been assessed starting from the mortality tables of ISTAT [22] by reparameterizing the values obtained with respect to the reference area. The "Health House 2.0" project will focus on coronary and cerebrovascular effects: therefore, the relative incidence rates have been identified (based on the Statistical Yearbook of the NHS [26]), and lethality has been reduced by 25%, obtaining a benefit of over € 2.6 million. This monetary amount is 37% higher than the corresponding financial savings of € 1.9 million. The benefits associated with the 150 patients related to the remote sensing have been set equal to the corresponding tariff return corrected for the conversion factor proposed by UVAL, and they have been estimated approximately equal to 460,000 euros/year.

Communities will visit the infrastructure, access the training events and get information about the activities and new publications through the advertising service and the website. The corresponding benefits, that is the marginal social value, is represented by the implicit willingness to pay of visitors, which can be estimated through the travel cost method.

It is assumed that the reference area is composed by the resident population in the Apulia region aged between 15 and 24 years old, and that every year there are about 2,000 entries (equal to 0.5% of the regional population between 15 and 24 years). As suggested by UVAL, the related benefits have been obtained by the sum of the cost per kilometer (equal to € 0.4944/km as indicated in the tables prepared by ACI [5] published in the Official Gazette of 02/03/2022) and the value of the time (assumed equal to 15 €/hour) both for the travel and for the visit (the total duration is assumed to be 2.5 h). The overall benefits have been assessed approximately equal to 290,000 euros per year.

Phase V: Analysis of the Economic Performance

The evaluation carried out has attested good economic performance of the project, as the Economic Net Present Value (ENPV) is equal to approximately € 12.6 million, the Economic Rate of Return (ERR) is equal to 12.0% and the Benefits/Discounted costs (B/C ratio) is equal to 1.3.

3 Conclusions

In the selection phase of the projects to be implemented through the support of EU funding, the importance assumed by the effectiveness of the ex ante evaluation techniques of different project solutions is always growing and strictly connected to an adequate use of the resources allocated by the EU for the realization of successful investments. The systematic and analytical process of comparing benefits and costs deriving from the realization of a project or programme allows to determine the contribution of the project to social well-being. The complexity that intrinsically characterizes urban initiatives and the tools used to decide, design and implement them underlies each intervention to be implemented on the urban territory (urban regeneration, disused property asset enhancement, construction or renovation of transportation infrastructures, recovery and protection of the environment, waste management, etc.), due to the contingent presence of public and private functions to be introduced, the heterogeneity of the subjects involved - Public Administration, private entrepreneurs, landowners, etc. – and of their interests, the scarcity of available financial resources and the different financing sources. From this perspective, each urban transformation initiative requires the definition and the management of several variables which, in different ways, concern the stakeholders involved and affect the overall investment feasibility [28, 30]. In the context of the territorial projects to be implemented, in general, and of the investments financed by the NRRP, assessment tools as the CBA aim to identify the one/s that are suitable of guaranteeing the economic and the financial convenience of the parties, in accordance with the urban and the natural environment identity.

With reference to the valuation of projects within the healthcare sector, the present research has developed a CBA on an initiative to be implemented through NPPR funds in a city situated in Southern Italy, by highlighting the convenience of the intervention for the investor ("financial" point of view) and the community ("economic" point of view). The analysis carried out, disaggregated in all the steps required by an effective CBA, could represent a manual for the evaluation of these typologies of investments, that can be consulted by private and public subjects, in order to appropriately verify the convenience of the initiative and its sustainability for the community, according to the market and socio-economic conditions of the context in which the project will be developed.

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