Economic Assessment of RDI Infrastructures

Silvia Vignetti, Director
CSIL

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Outline

- Background
- Definition, types and key features
- Context analysis and project identification
- Demand analysis
- Option analysis
- Financial analysis
- Economic analysis
- Risk assessment

Background

- RDI at the core of policy agenda
- Increasingly expensive facilities for experimentation
- High expectations and large international cooperation
- Opportunity-cost of decision
- Scientific community and policy-makers in a bargaining system
- Use of CBA is in its infancy

Definition

- **Science-related infrastructures** developed with the main purpose of acquiring **new knowledge** in a given **scientific and technological field**

  - for fundamental research
  - for applied research and experimental development

- **Innovation infrastructures** combining knowledge and technology for new products, processes and services

Types of RDI infrastructure and projects

- Research and development infrastructures
  - Centres and laboratories specialised in a specific field
  - R&D centres for research organisations
  - Equipment for developing innovation
- Innovation infrastructures
  - Equipment for single private enterprises to support the development of innovative services
  - Technology park

Types of RDI infrastructure and projects II

- Infrastructures for research, development and innovation
  - Science and technology park
  - Laboratories for aggregations of private entreprises, research institutes and universities
  - Research centre with aplications of research outputs to final users

Types of RDI infrastructure and projects

Fundamantal research

- Particle accelerators and synchrotrons
- Telescopes
- Satellites and aircraft observation facilities

From LEP to **LHC**

Applied research and development

- University research laboratory
- Clean rooms for the study and development of new materials or nano-electronics
- Observatories for environmental sciences
- High-intensity lasers

CNAO National Hadrontherapy Center for Cancer Treatment

Innovation

- Technology Park
- Science Park
- Business Incubation Centre

ESA Business Incubation Centre Lazio

Key features

- High capital intensity and long-lasting facilities and equipment
- Multifaceted nature
  - different categories of target groups
  - different scientific fields
  - single-sited, distributed and virtual
- High risk and uncertainty
- Knowledge as intangible public good

Main policy long-term objectives

- National research system more effective through cooperation, mobility and access to knowledge within European research area
- Increase technological spillovers potentially generated from large-scale RDI infrastructures
- Reduction of the permanent brain drain in certain geographical areas
- Smart specialisation, advancement of knowledge and high levels of employment

Context Analysis I

- **Socio-economic** trend important for the assessment of existing research and starting point for the project appraisal

Information related to:

- Demographic and Educational statistics
- National and Regional GDP growth
- Gross domestic expenditure in R&D

- **Policy and Legislative** framework

Information related to:

- EU sector policy documents
- Regional and Innovation Strategy for Smart Specialisation
- State aid legislation

Context Analysis II

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- **Geographical** conditions and **availability** of resources

Information related to:

- Geographical proximity to industries and research laboratories to favour networking
- Accessibility
- Availability of technical engeneering expertise

- **Level** of research and innovation

Information related to:

- Percentage of employees in the R&D sector
- Knowledge intensity of business

Context Analysis III

- **Conditions** of existing research facilities and infrastructural needs

Information related to:

- State and number of the existing infrastructures
- Benchmarking with other RDI infrastructures operating in the same field
- Past and present scientific activity
- Cooperation with existing entities

Project identification

- **Single-site facilities** => project identification becomes straightforward
- **Distributed facilities** => the project can be identified as a self-sufficient project if there is a strong functional relationship among all of its parts
- **Investments aimed at fostering cooperation between a number of research facilities** => can be considered as a single project and a self-sufficient unit of analysis for the purpose of the CBA, as long as they create strong synergies, critical mass and achieve cost savings for each facility involved

Demand analysis I

The demand of RDI infrastuctures is driven by three macro categories of target groups, which are:

- Business (SMEs, large entreprises, high-tech business, spin-offs)
- Researchers, young professionals and students
- Target population and the general public (direct and indirect target of research)

Demand analysis II

- Business

Factors driving the demand

- Average growth of the industrial base in the RDI project field in the last years
- Access to venture capital funds
- Level of public investment in fields related to the RDI project

Methods for data gathering

- Statistical analysis of historical data
- Smart specialisation
- Financial information and benchmarks with similar RDI projects

Output

- Annual number of spin-offs/start-ups
- Expected number of user businesses, non-users and patents

Demand analysis III

- Researches, young professionals and students

Factors driving the demand

- Number of scientists operating in the RDI project
- Number of existing facilities and scientific potential of RDI infrastructures
- RDI capacity to attract funding and users

Methods for data gathering

- Demographic projections
- Surveys and consultations to access the attractiveness of the RDI sector among students

Output

- Annual number of researchers (direct-user)
- Annual number of students and young professional who will use the RDI infrastructures

Demand analysis IV

- Population and General Public

Factors driving the demand

- Attractiveness of the RDI infrastructure among the wider public
- Number of people affected by environmental and health risks

Methods for data gathering

- Statistical analysis of historical data
- Benchmarks with similar RDI projects
- Interviews and surveys

Output

- Annual number of people potentially targeted by the project
- Annual number of patients treated by innovative medical technologies

Demand analysis V

- Population and General Public

Factors driving the demand	➢ Attractiveness of the RDI infrastructure among the wider public ➢ Number of people affected by environmental and health risks
Methods for data gathering	➢ Statistical analysis of historical data ➢ Benchmarks with similar RDI projects ➢ Interviews and surveys
Output	➢ Annual number of people potentially targeted by the project ➢ Annual number of patients treated by innovative medical technologies

Option analysis

The project, proposed for implementation, should be justified among a number of alternative options:

- **Strategic options**: a set of alternatives concerning the structure of the project
- **Technological options**: a set of alternatives concerning different technologies to be purchased by the project
- **Location options**: a set of alternatives concerning the location of the project
- **Architectural options**: a set of alternatives concerning the architectural design of the building where the project is located

Financial analysis I

Investment cost

- Planning and design costs
- Land acquisition
- Construction costs, possibly disaggregated by civil works and installations, materials, labour, etc.
- Energy, waste disposal and other utilities consumed during the construction period
- Road access
- RDI equipment, including information technologies (particularly for data storage or elaboration)
- Intellectual property purchase costs
- Testing
- Start-up costs

O&M costs

- Materials and equipment
- Consulting services
- Cost of scientific personnel
- Cost of administrative and technical staff
- Cost of obtaining and maintaining patents
- Energy, waste disposal and other utilities
- Promotional campaigns and other outreach expenditure targeted to the general public
- Training courses connected to the infrastructure's operation and management
- Removal of potential pollutions / brownfield site treatment at the end of the life cycle of the infrastructure

PAY ATTENTION TO SUNK COSTS AND IN-KIND CONTRIBUTIONS

Financial analysis II

Examples of operating revenues

- Licence revenues gained from patents' commercialisation
- Sale of consultancy services
- Revenues from industrial research contracts and pre-commercial procurement contracts
- Entry fees to the laboratory and for the use of research equipment charged to researchers and businesses
- Student/master/PhD fees
- Spin-off equity realisations
- Revenues from the target population using the research outputs (e.g. patients receiving an innovative treatment)
- Revenues from outreach activities to the wider public (e.g. bookshops' sales, entry fees, etc.)
-

Examples of financing sources

- National/regional public contributions
- National/regional private contributions
- EU contribution
- Other national/regional funding schemes for RDI activities
- Ordinary public transfers

DON'T CONFUSE!

Operating revenues vs. financing sources

Examples of flows to be considered operating revenues for the project:

- grant awarded by a national / regional public agency to a public research body, directed to the development of a new product/service usable in the national / regional area;
- contributions paid by technology-based companies involved in co-development of equipment, software, services etc. to be able to use them as out-of-the-box products in the future.

Examples of flows to be considered financing sources for the project:

- grants from European / national / regional research funding frameworks (e.g. Horizon 2020);
- loans from banks or financial institutions acting as intermediary of public bodies;
- regular or exceptional donations from the State Agencies;
- donations from charity bodies and philanthropic organisations.

Basic principles of economic analysis

- While financial analysis determines whether project **<u>needs</u>** an EU grant, the economic analysis is about measuring in "money terms" all the benefits and costs of the project to society

- Four basic steps:
  1. Economic Costs
  2. Economic Benefits
  3. ENPV and ERR
  4. Sensitivity and Risk Analysis

Economic analysis: benefits to business I

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➢ **Establishment of spin-offs and starts-ups**

- Spin-offs and starts-ups considered under the same typology of benefit for the purpose of CBA
- Economic value of spin-offs and start-ups assessed as the **expected shadow profit** generated by the business during its lifetime, as compared to the counterfactual situation.

Economic analysis: benefits to business II

- **Development of new/improved products and processes**

  Two approaches for estimating such benefits:

  - Changes in **shadow profit expected for the sale of** marketable **goods** associated with the R&D activity
  - **Value of patents** that may arise from R&D activity

The value of new scientific publications

- The maginal of scientific publications is estimated on their **marginal production costs** which is the salary of the author prorated by the time spent working on a publication.

Other knowledge outputs, such as working papers, pre-prints and talks at conferences, can also be considered and valued according to the same marginal production cost approach

Economic analysis: benefits to researchers and students

- **Human capital formation**

  Two approaches for estimating such benefits:

  - The premium is **the incremental lifelong salary** earned by young researchers and students over their entire work career, as compared to the counterfactual
  - Estimating the **WTP** for junior researchers and students to attend a training period at RDI infrastuctures

- **Social capital development**

  - Social capital in the context of research infrastructures as the **creation of networks between researchers and business**

  Assessment in qualitative terms?

Economic analysis: benefits to the general public I

- **Reduction of enviromental risks**

Some research infrastructures focused on programmes targeted at the reduction of enviromental risks (e.g. climate change, landslides, forest fires, etc.) and studing the mitigation measures.

- **Per capita avoided cost** of the population potentially targeted or their **WTP** to reduce enviromental risks can help to quantify such risks

The quantification of benefits related to reduction of enviromental risks is subject to high uncertainty

Economic analysis: benefits to the general public II

➢ **Reduction of health risks**

Some research infrastructures focused on health related issues (e.g. hospital research laboratories, medical research facilities)

- As with standard health projects, the project's marginal benefit is **the reduction of mortality** or **morbidity rates** or **improved health conditions**

The quantification of benefits related to reduction of health risks is subject to high uncertainty

Economic analysis: benefits to the general public III

➢ Cultural effects for visitors

Some RDI infrastructures attract the interest of the general public and their management may have an outreach strategy to this end.

- The marginal social value of the benefit is the visitors' implicit **WTP**

Benefits and costs of RDI projects: regional perspective

- **Externalities**: environmental impacts during the construction, operation and decommissioning phases, such as air/soil/water pollution, GHG emissions and noise.
- **Pecuniary externalities**: effects on real estates
- Impact on **regional competitiveness**
  - attraction of scientists, technological experts and skilled personnel
  - employment effects
  - attraction of capital or new businesses
- **Wider regional effects**: demonstration effects, social capital, quality of institutions

Risk assessment

Errors related to the estimation of costs and benefits generated by RDI infrastructures could be relevant from an ex ante perspective.

The probabilistic risk analysis should include the following two steps:

- **Sensitivity analysis** to identify the most critical variables of the CBA model
- **Risk analysis** based on Monte Carlo simulation providing probability distributions of CBA model results

The PDF and CDF of the project's NPV (or IRR) allow for the assessment of the project risk by verifying whether it is higher of lower than a reference value.

Sensitivity analysis

- This shows the change in IRR as a function of the arbitrary change in the random variables (considered one by one) see if the impact is modest or highly significant
- Critical variables are those for which a positive or negative growth could mostly affect IRR and NPV, making them vary in a relevant way.
- As general simple criteria: choose critical variable for which a variation of 1% (+/-) cause 5% (+/-) of NPV.

Risk assessment

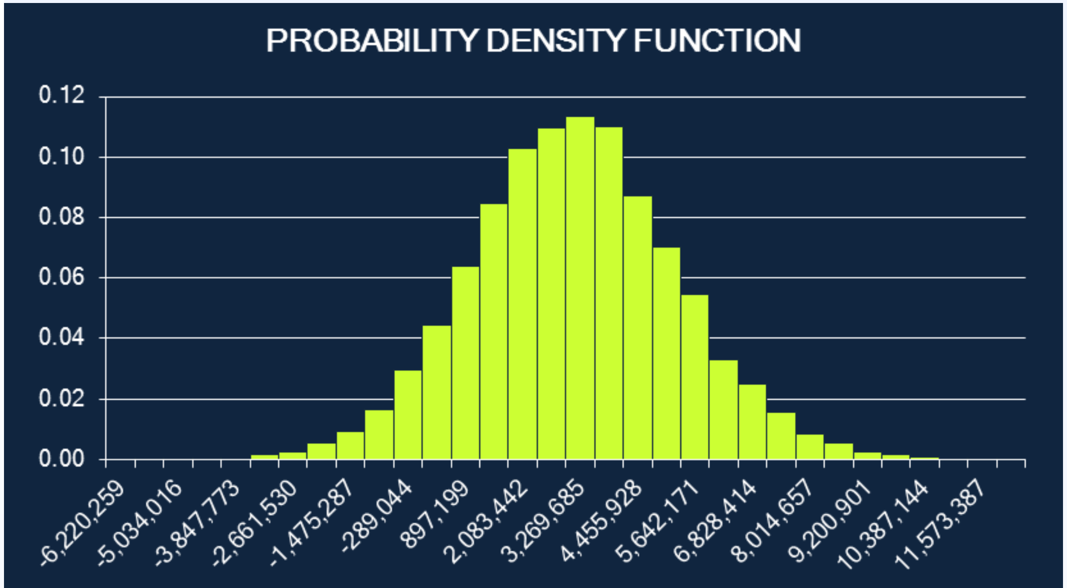
- Risk matrix
- Identification of prevention and/or mitigation measures

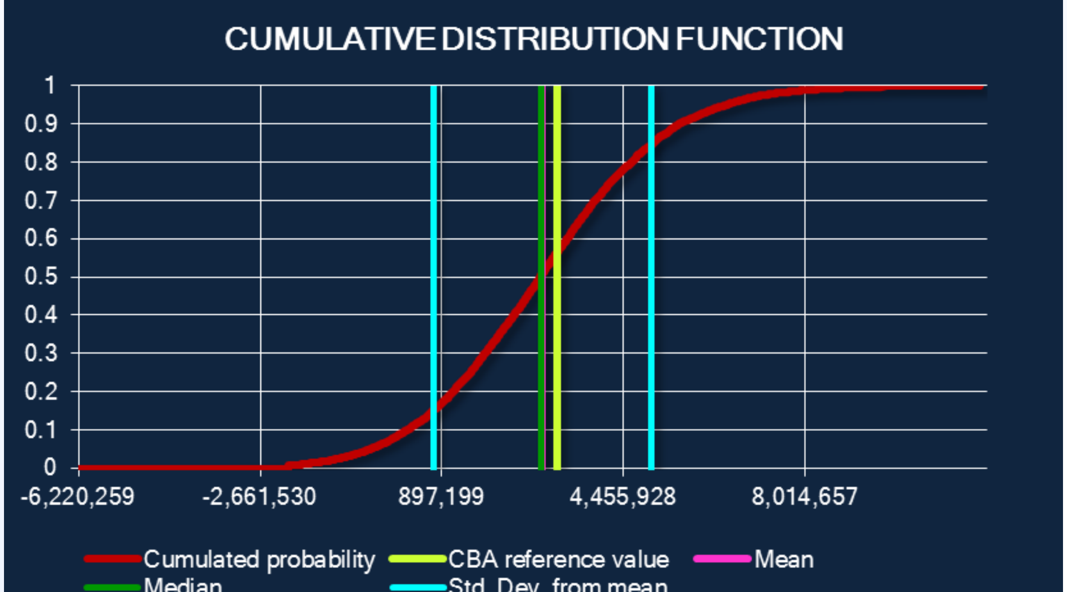
Severity / Probability	I	II	III	IV	V
A B C D E	Prevention or mitigation Prevention		Mitigation Prevention and mitigation		

Risk assessment

Adverse event	Variable	Causes	Effect	Probability (P)	Severity (S)	Risk Level	Prevention and/or Mitigation measures	Residual risk
Construction delays	Investment cost	Low contractor capacity	Delay in service start Delay in establishing a positive cash flow including benefits materialisation	C	III	Moderate	Set up of a Project Implementation Unit to be assisted by technical assistance for project management during implementation.	Low
Project cost overrun	Investment cost	Inadequate design cost estimates	Investment costs higher than expected	D	V	Very high	The design of the project must be revised.	Moderate

Risk assessment: Outcome example

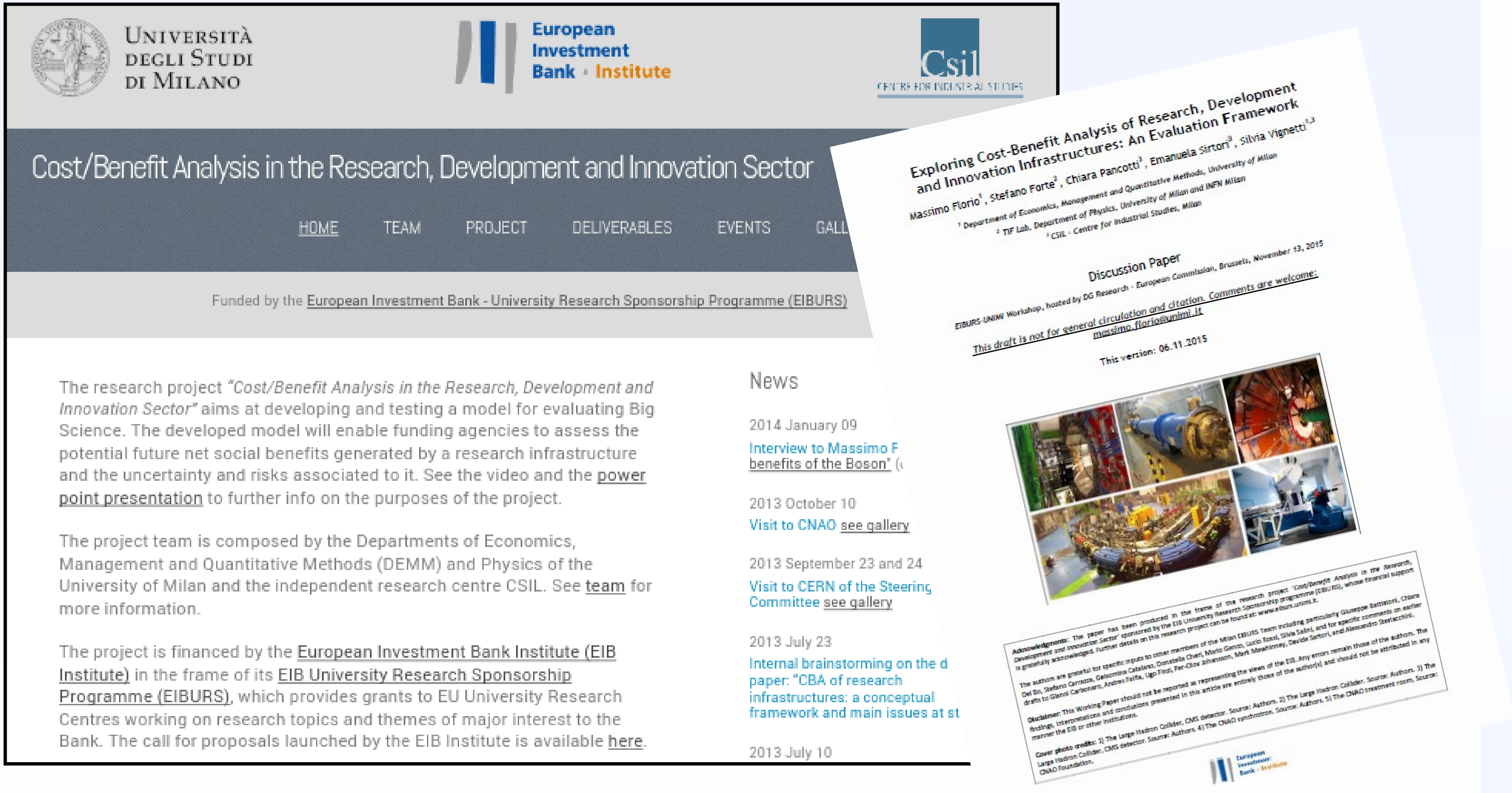




EXAMPLE OF THE PROBABILITY DISTRIBUTION OF THE NET PRESENT VALUE

ESTIMATED PARAMETERS OF DISTRIBUTION	
Mean	2,855,528
Median	2,825,860
Standard deviation	2,134,763
Minimum	-6,220,259
Maximun	11,573,387
ESTIMATED PROBABILITIES	
Pr. ENPV ≤ 0	0.086

Further research in progress



http://www.eiburs.unimi.it/




For info or further questions:

Silvia Vignetti
vignetti@csilmilano.com

Massimo Marra
NCC Senior Officer
ph: +352 4379 85007
mail: m.marra@eib.org

www.jaspers-europa-info.org

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JASPERS Networking and Competence Centre

jaspersnetwork@eib.org

www.jaspersnetwork.org