Università degli Studi di Milano
Jean Monnet Centre of Excellence
"The impact of European Union Research and Innovation Policy upon Services of General Interest"
With the support of the Erasmus+ Programme of the European Union

Modulo 3
Studio di casi

Lezione 3.10

Cnao: un sincrotrone per l’adroterapia del cancro (Pavia)

CNAO - National Hadrontherapy Center for Cancer Treatment

- It is an **applied research facility** specialised in **hadrontherapy**, an advanced oncological treatment showing clinical advantages as compared to traditional radiotherapy.
- It comprises two broad distinct areas: the **high technology components**, made of a set of **accelerators and transport lines of particle beams**, and a **clinical 'day hospital' facility**, comprising reception desks, waiting and changing rooms.

Terapia

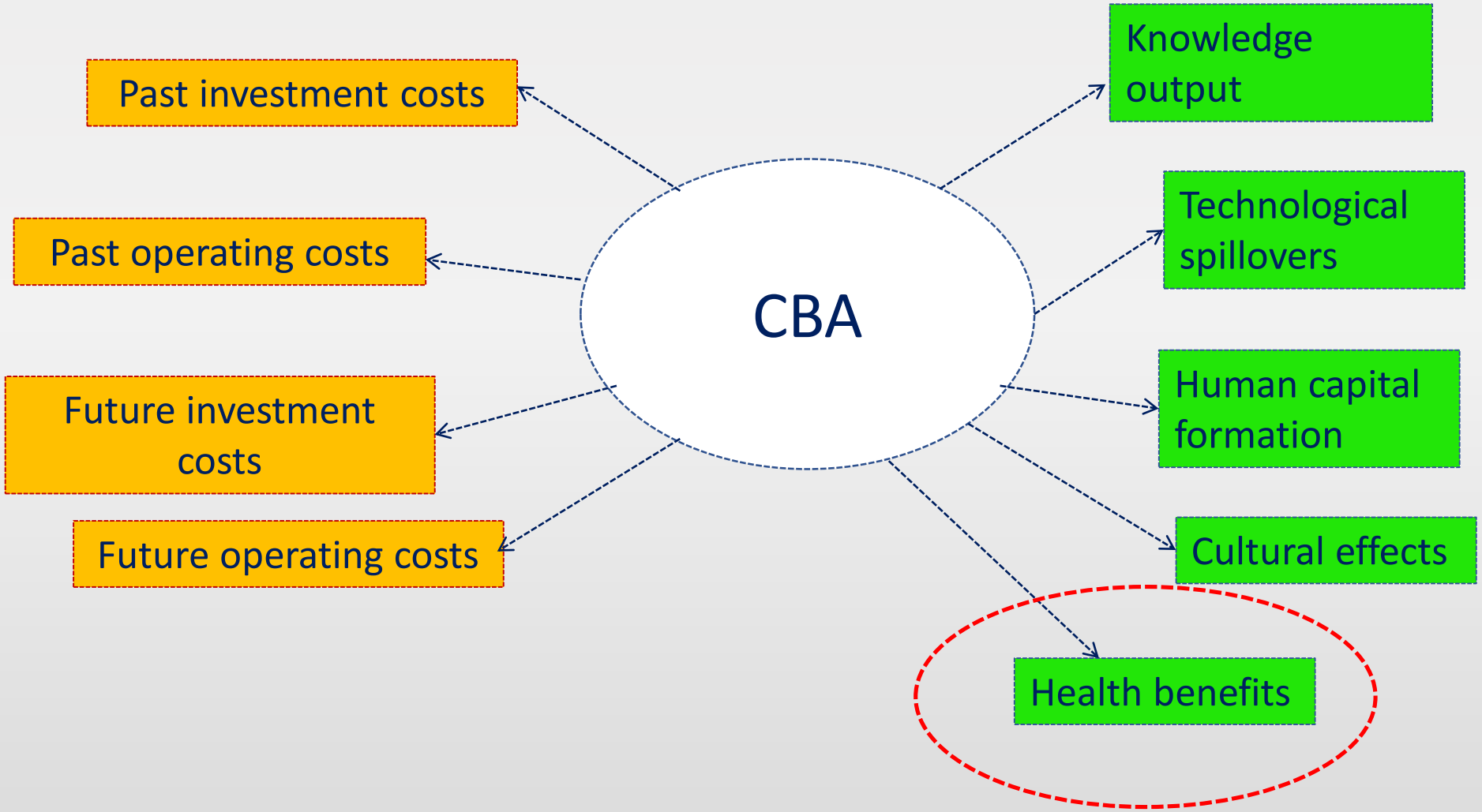
Il trattamento di adroterapia

- L’adroterapia è una forma avanzata di radioterapia impiegata nel trattamento:
- - di tumori radioresistenti quelli cioè che non rispondono con successo alla radioterapia con raggi X
  - di tumori inoperabili (per estensione di malattia o giudicati operabili, ma con esiti invalidanti per il paziente)
- L’adroterapia grazie alle proprietà fisiche delle particelle utilizzate (adroni) presenta alcuni importanti vantaggi rispetto alla radioterapia con raggi X:
- • consente di **trattare i tumori situati in sedi critiche** (cioè in prossimità di organi vitali come encefalo, tronco encefalico, midollo spinale)
  • permette di **salvaguardare i tessuti sani**, grazie ad un rilascio della dose terapeutica estremamente selettivo.
  • **riduce il rischio di sviluppare tumori secondari** (potenzialmente indotti delle basse dosi di radiazioni sui tessuti sani circostanti)

Terapia (segue)

- Gli **effetti collaterali** dell'adroterapia possono variare a seconda del distretto trattato e nella maggior parte dei casi sono di modesta entità.
- Le **patologie trattabili** con adroterapia presso il CNAO sono rimborsate dal SSN, in quanto rientrano nei Livelli essenziali di assistenza (LEA) (approvati nel decreto del Presidente del Consiglio dei Ministri del 12 gennaio 2017 (GU n. 65, Suppl ordinario 1S, 18 marzo 2017).
- http://www.gazzettaufficiale.it/eli/id/2017/03/18/17A02015/sg
- https://fondazionecnao.it/adroterapia-italia-entra-lea
- Presso CNAO inoltre sono trattabili altre patologie
  - tumori della prostata ad alto rischio
  - tumori al pancreas
  - neoplasie ginecologiche
- nell'ambito dei relativi **studi clinici** in corso

The ingredients of CNAO CBA



Parametri dell'analisi

TIME HORIZON	30 years: 2001 - 2031
UNIT OF ANALYSIS	the hall hosting the particle accelerators and the other areas functional to the proper functioning of the clinical facility
SOCIAL DISCOUNT RATE	3% in real terms (adopted by the EC CBA Guide, 2014)
SHADOW PRICES	Proxied by marginal WTP or marginal costs
COUNTERFACTUAL	Do-nothing"
Non-use benefits	assumed 0
NEGATIVE EXTERNALITIES	assumed 0

Cost–benefit analysis of applied research infrastructure. Evidence from health care
Giuseppe Battistoni, *Mario Genco* , *Marta Marsilio*, *Chiara Pancotti*, *Sandro Rossi* and *Silvia Vignetti*
Technological Forecasting and Social Change, 2016, vol. 112, issue C, 79-91

CNAO: Estimation of health benefits

Type 1 – FULL RECOVERY
Marginal benefit by protocols

# of protocol	Clinical alternative	Marginal percentage of patients who fully recover compared to the counterfactual situation
1	No alternative	73%
2	No alternative	73%
3	No alternative	33%
9	Surgery + photon therapy	45%
10	Surgey	21%
11	No alterative*	45%
12	No alterative*	14%
15	Surgery + photon therapy	30%
16	Photon therapy	43%
13	No alterative*	33%
19	Photontherapy	36%

Type 2 – INCREASE IN LIFE EXPECTANCY
Marginal benefit by protocols

# of protocol	Clinical alternative	Marginal percentage of patients who fully recover compared to the counterfactual	Number of life years gained with respect to the counterfactual
6	No alternative for advanced tumours	15%	5
8	No alterative	43%	3
14	No alterative*	68%	0.5
18	Palliative chemotherapy	40%	2
20	No alterative	43%	3
22	Surgey + photon therapy	10%	5
23	Photontherapy*	35%	5

Type 3 – BETTER QUALITY OF LIFE
Marginal benefit by protocols

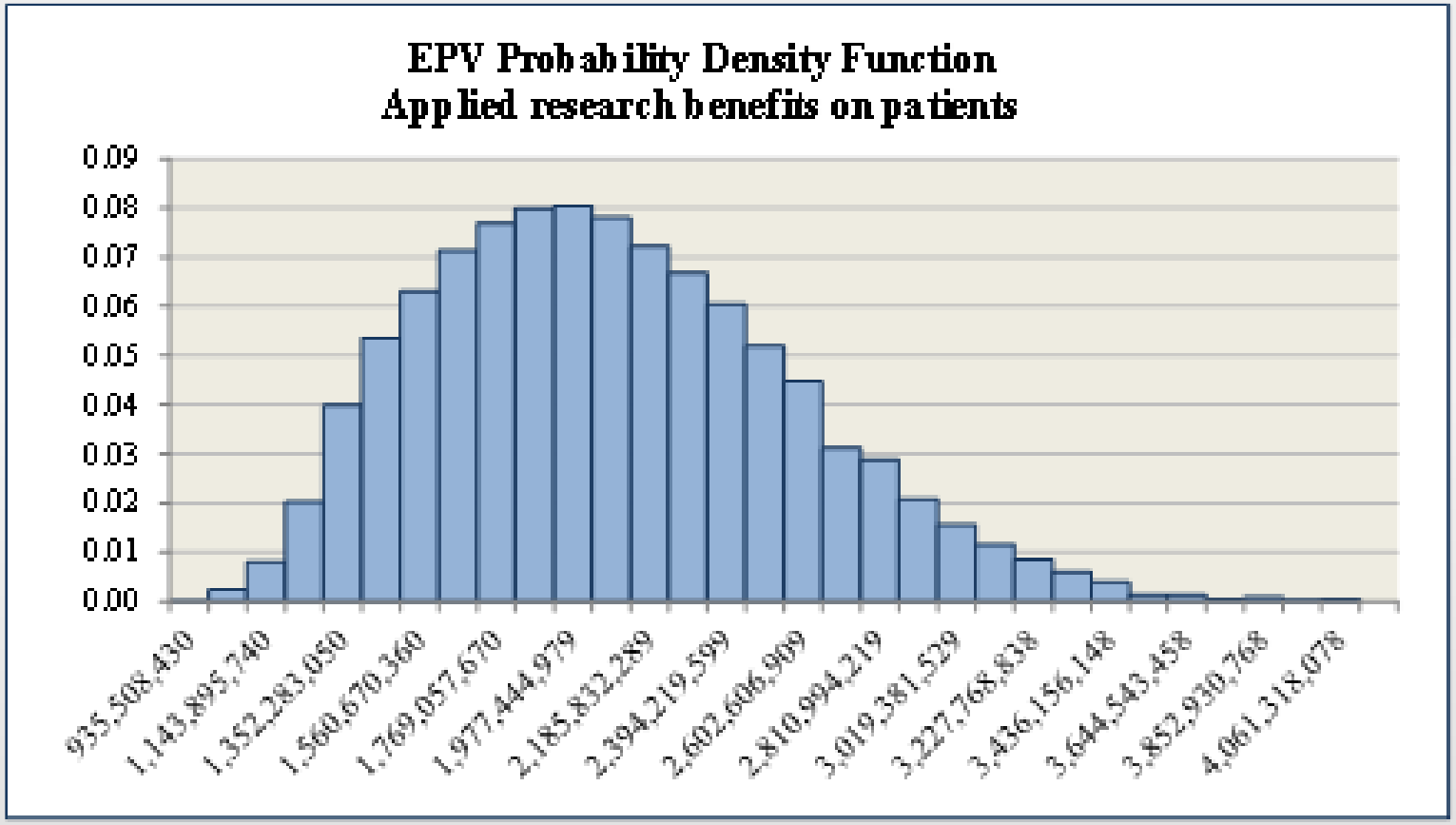
# of protocol	Clinical alternative	Marginal percentage of patients who fully recover compared to the counterfactual	Number of life years gained with respect to the counterfactual	Quality of life adjustment factor*
7	No alterative	100%	1	0.3
21	Surgey	100%	15	0.3

Stima dei benefici sanitari

$$A = \sum_{t}^{T} \frac{\sum_{p}^{P} \sum_{i}^{I} \left(N_{p,i} * E_p\right) * \left(X_{pi} * VOLY_i\right) * Q_p}{(1 + 3\%)^t}$$

N: number of patients
E: share of patients who gain additional years of life compared to the identified counterfactual
X: number of life years gained
VOLY: Value of Statistical Life Years
Q: coefficient capturing the increased quality of life
p (1, ..23): clinical protocol
i (1, ..6): age class
t (1, …30): year of time horizon

Analisi del rischio



Probability distribution of applied research benefits on patients (Euros)

Estimated parameters of the distribution

Mean	2,028,626,666
Median	1,984,699,763
Standard deviation	495,675,860
Minimum	935,508,430
Maximum	4,061,318,078

Estimated probabilities

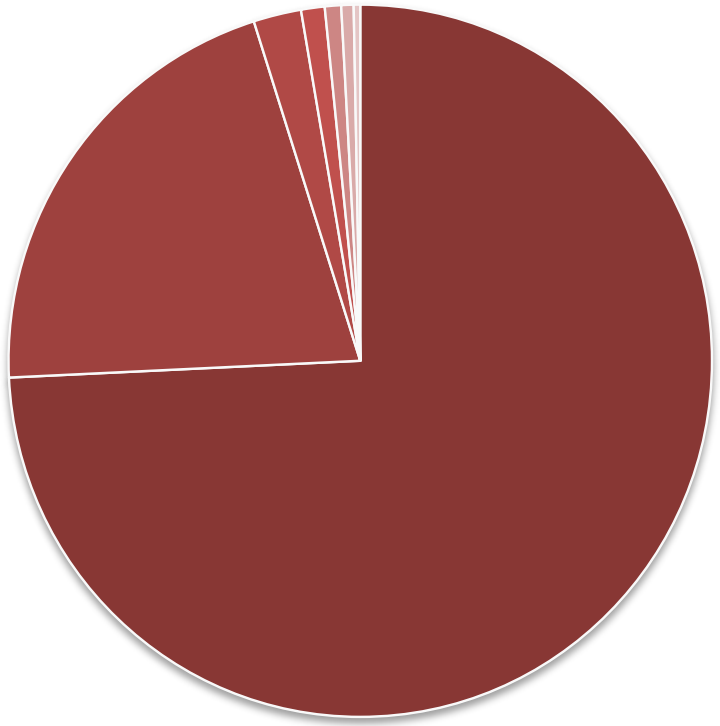
Pr. EPV ≤ base value	0.480
Pr. EPV ≤ 0	0.000

CNAO: CBA Results

- Carbon Ion Therapy 74.2
- Proton Therapy 20.9%

Health benefits

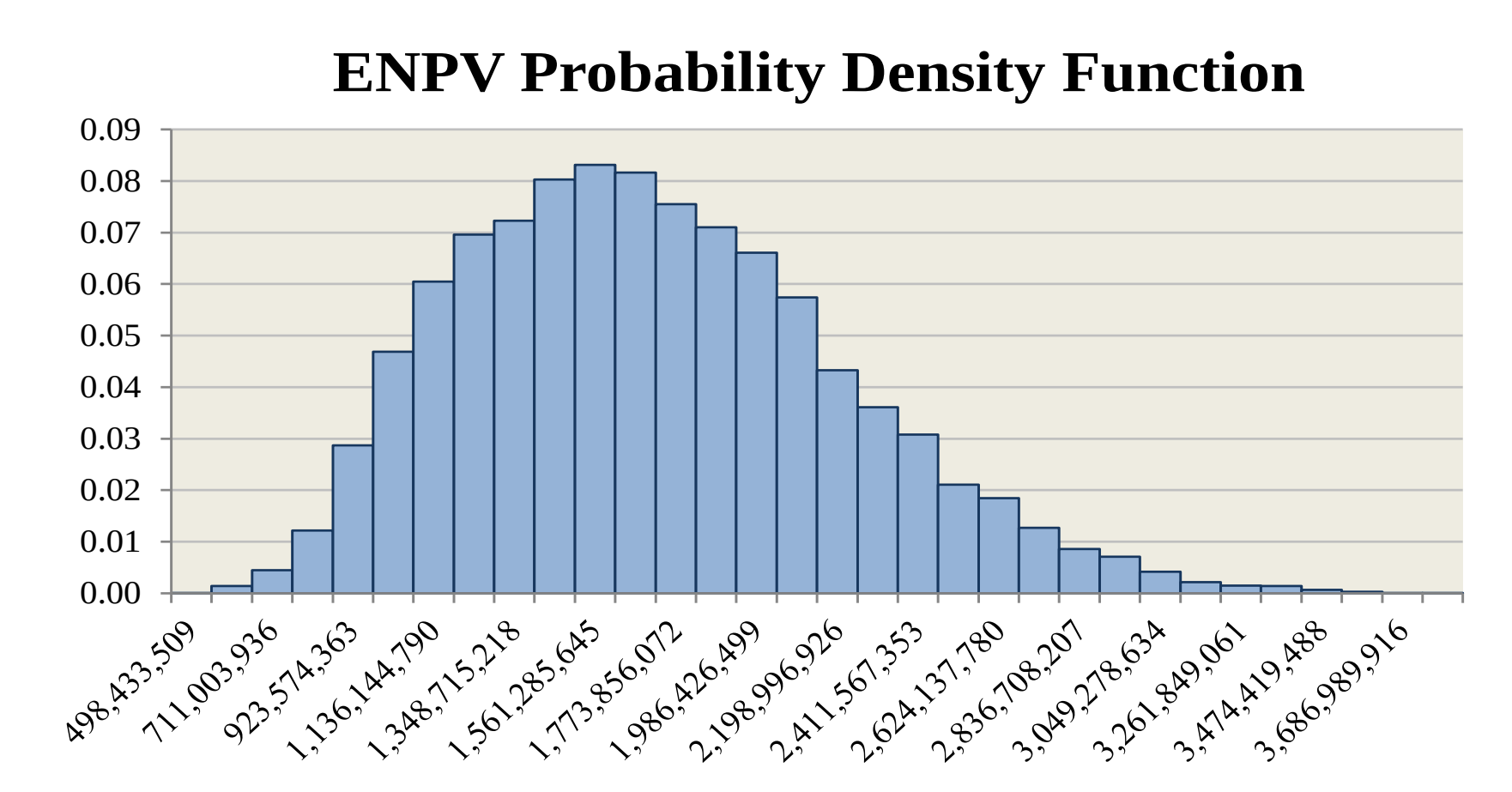
- Revenues 2.2%
- Benefit of Technological Spillovers 1.1%
- Benefit of Human Capital Generation 0.7%
- Benefit of Knowledge Creation 0.6%
- Benefit of Cultural Outreach 0.3%



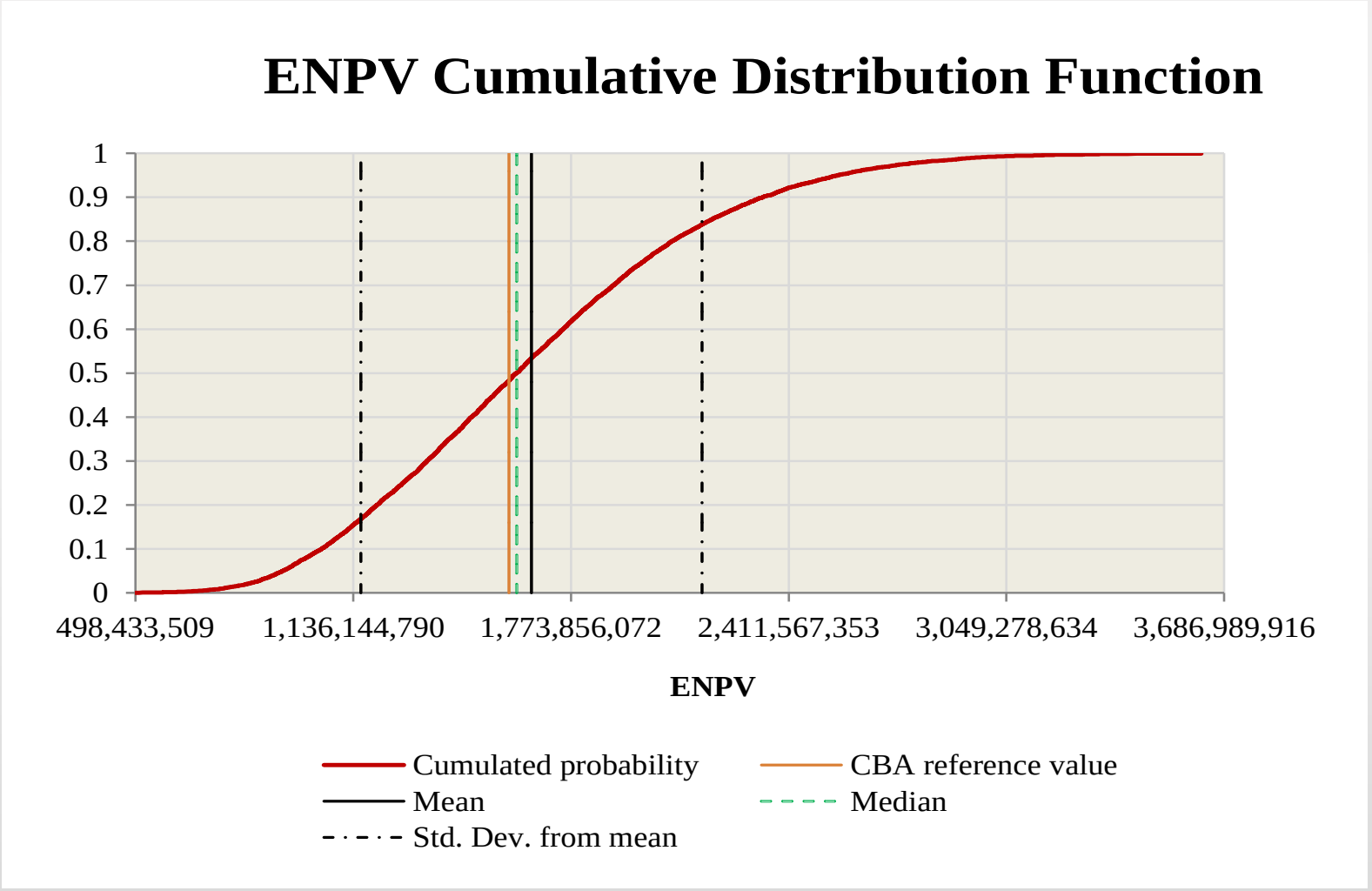
Estimated parameters of distribution	
Mean	1,658,358,087
Median	1,615,046,849
Standard Deviation	499,225,618
Minimum	498,433,509
Maximum	3,686,989,916
Estimated probabilities	
Pr. ENPV ≤ 0	0.483

Probability distribution of the CNAO net present value

- Own estimate of the Present Value PDF resulting from a Monte Carlo simulation (10,000 random extractions)



Cumulata


ENPV Cumulative Distribution Function
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
498,433,509
1,136,144,790
1,773,856,072
2,411,567,353
3,049,278,634
3,686,989,916
ENPV
Cumulated probability
CBA reference value
Mean
Median
Std. Dev. from mean