Directorate General
European Programmes,
Coordination and Development

Introduction to Investment Appraisal

Course Material and Examples

Instructor:
Savvas Zannetos, Ph.D.

Nicosia
June, 2018

Why?

Russky Island Bridge

>$1.000.000.000

50.000 vehicles/day

Serves an island of 5.000!!!

Madrid “Radiales”

- Toll motorways alongside existing free expressway and national road

THE DIPLOMAT IN SPAIN

User
Password
Reme

Jueves, November 30, 2017

Frontpage | News ▾ | Tribune | Embassies ▾ | Services ▾ | VIP Club ▾

Frontpage /

The failure of toll roads will cost the State 4,280 million

29 octubre, 2014 | Frontpage, Spain | 0 Comments

Banks will forgive 50% of the 4,000 million debt of the concession companies./ Photo: La Razón.

Αεροδρόμιο **Castellón (€150 εκ.)**
Επίσημα επιχειρησιακό: Μάρτιος 2011
Πρώτη πτήση: 14 Ιανουαρίου 2014 !!!!!

Brazil's World Cup Stadiums Were A Colossal Waste Of Money

Billy Haisley
5/12/15 2:46pm · Filed to: 2014 WORLD CUP

One of the major concerns of the Brazilian people in the run-up to last summer's World Cup was the prudence of a financially-troubled nation spending hundreds and hundreds of millions of dollars on stadiums. The stadiums were criticized for their opulence, their number, and their location. As it turns out, the critics were right.

NPR has a report updating us on the stadium situation in Brazil. The picture is bleak.

> The most expensive World Cup stadium — located in the capital, Brasilia, and with a price tag of $550 million — is being used as a parking lot for buses.
>
> The stadium in Cuiaba — which cost some $215 million to build — has made news repeatedly: first for being closed down because of faulty construction, and then recently for the homeless people squatting in its unused locker rooms.

nent

Berlin Brandenburg Airport

15 years of planning

Construction began in 2006

Originally planned to open in October 2011

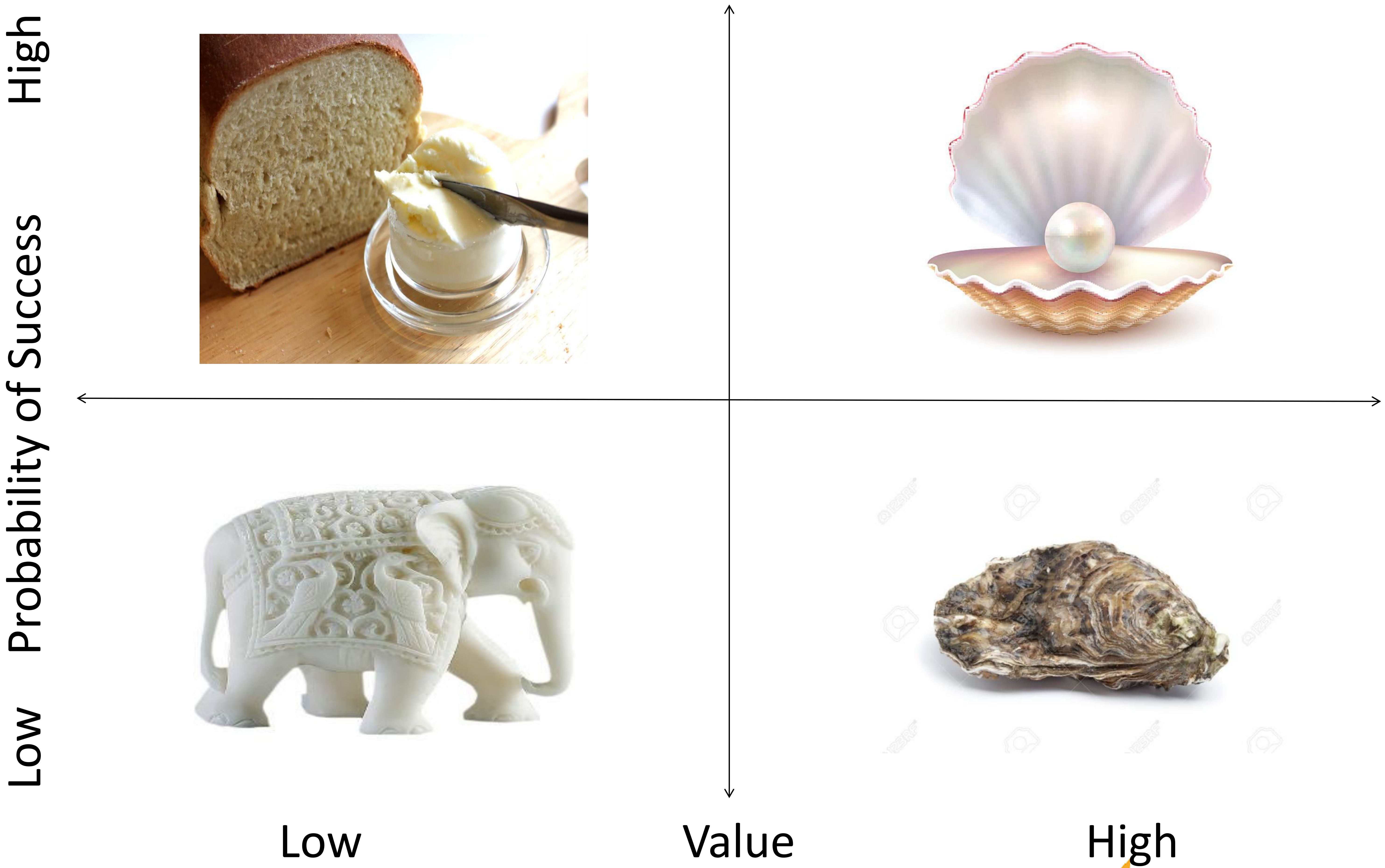
Autumn 2020 became the new official opening date

€20 million/month

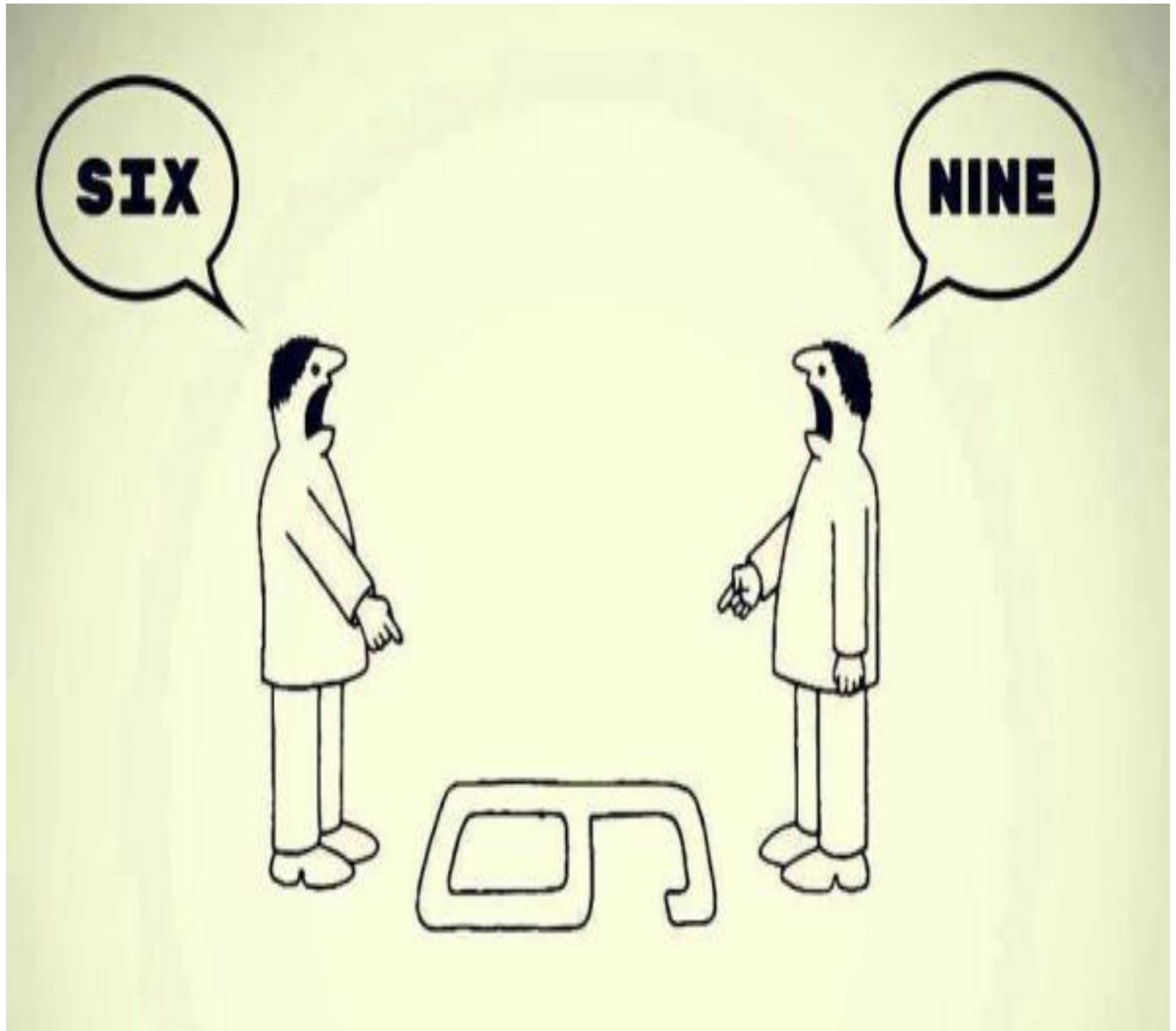
What happened?

White elephants… This is what we want to avoid!!!!

What do we want?


High
Probability of Success
Low
Low
Value
High

Public Investment Management



Bureaucrats have a tendency to see “costs” and “benefits” differently depending on their position or agency

Most have no formal training on Cost Benefit Analysis

Public Investment Management

Guardians

Spenders

Public Investment Management

Guardians

Often found in Budgetary Departments

Benefits = Revenue Inflow

Costs = Revenue Outflows

- Budget Impact Analysis

Problems arise when a Guardian does Budget Impact Analysis while thinking he is performing a Cost Benefit Analysis

Public Investment Management

Spenders

Often found in line Ministries

Builders or professional deliverers of government projects

Regard Expenditures as Benefits rather than Costs (eg labour)

Tend to support any alternative rather than the status quo (no project)

Public Investment Management

Cost Benefit Analysis - Perspectives

Cost Benefit Analysis – Perspectives - Company

- Own Benefit
- Maximizes the amount of money they can make
- Costs (wages, purchases, rent, taxes etc.)
- Benefits (Sales, services, Interest, government subsidies, etc.)

Cost Benefit Analysis – Perspectives - Bank

- Own Benefit
- Maximizes the amount of money they can make
- Costs (wages, rent, interest paid to customers etc.)
- Benefits (interest earned from customers etc etc.)

Cost Benefit Analysis – Perspectives - Government

- Maintains order in the Society
- Police, Military, etc.
- Concerned with Externalities
  - Taxes negative externalities
  - Subsidizes /supplies positive externalities
- From CBA point of view (financial)
  - Costs (subsidies, costs involved in any new duties because of new project
  - Benefits (taxes, fines etc.)
- Measures Costs and Benefits in terms of what is going in and out of the Treasury. Government is not incentivize to maximize the amount of money in the Treasury

Cost Benefit Analysis – Perspectives - Society

- Resource is a good or service with value to society (= humans)
- Does a project uses more or less resources than it creates?
- If it creates more resources than it uses then a Net Benefit
- If it creates less resources than it uses then a Net Cost

Cost Benefit Analysis – Perspectives - Society

Interactions that do not increase or decrease resources to society

- Transfer of money
  - Subsidies
  - Taxes
- Example. Subsidy is a cost for the Government (government perspective), a benefit for the Company (company perspective)
- Social Perspective ➔ no effect (just a transfer of money)
- Same for taxes, financing
- Includes non-market valuation
- Shadow Prices

Social = Economic Perspective

Let’s Practice!!!

Perspectives

Imagine that you live in a city that currently does not require bicycle riders to wear helmets. Furthermore, imagine that you enjoy riding your bicycle without wearing a helmet.

1. From your perspective, what are the major costs and benefits of a proposed city ordinance that would require all bicycle riders to wear helmets?
2. What are the categories of costs and benefits from society's perspective?

Financial vs Economic Analysis

Major Differences between Financial and Economic Cost-Benefit Analysis

	Financial Analysis	Economic Analysis
Perspective	Agency/organisation/firm	Economy/society
Objective	Analysis of the net financial impact of the proposal on the agency	Maximising the social returns to the economy's resources
Pricing	Market prices	Opportunity costs/shadow prices
Transfer payments (taxes & subsidies)	Included	Excluded
Equity/distributional effects	Excluded	Can be included, usually treated qualitatively
Externalities	Excluded	Included
Depreciation	Excluded (from discounted cash flow analysis, but included in financial statements).	Excluded

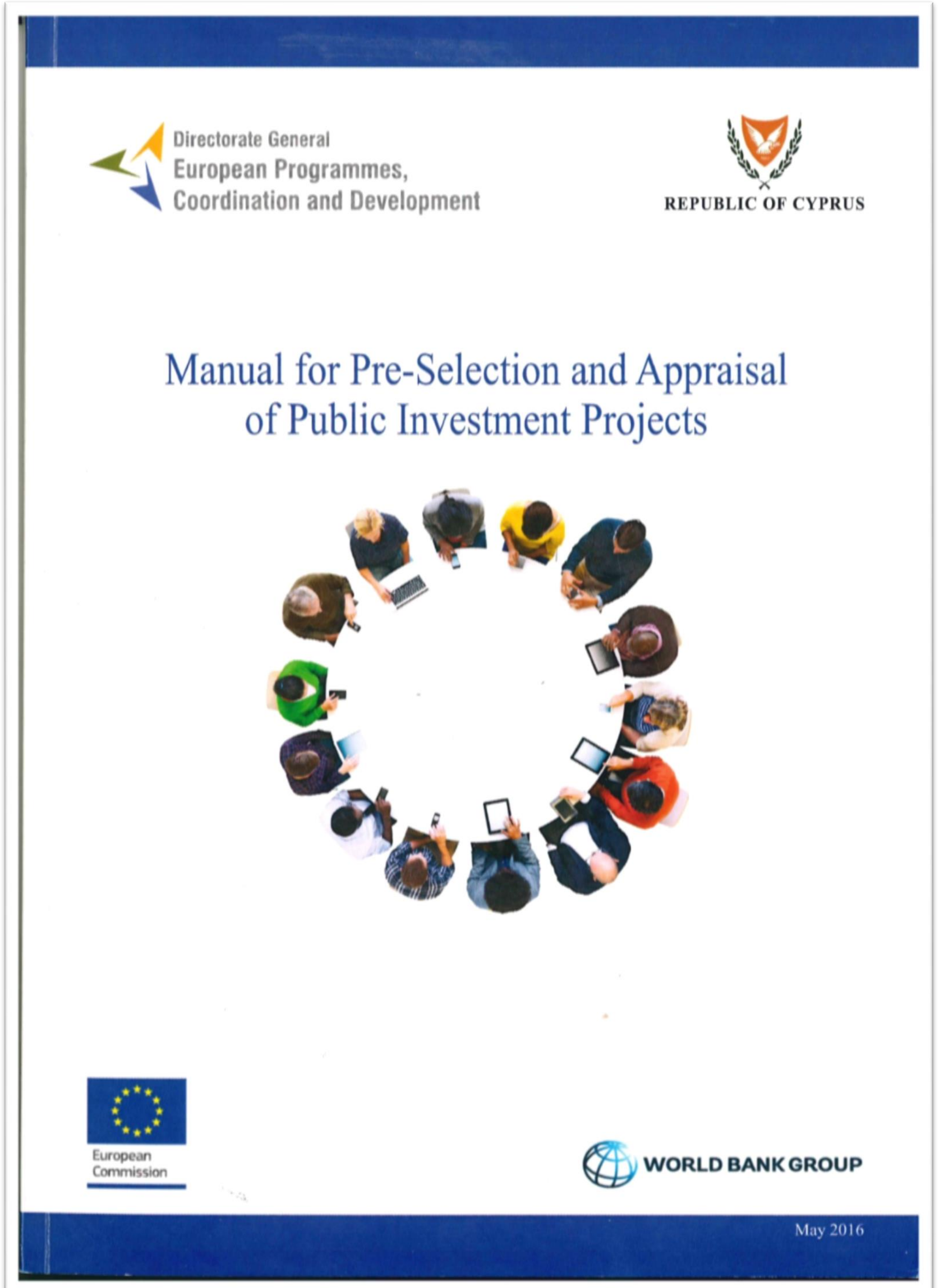
What is Cost Benefit Analysis?

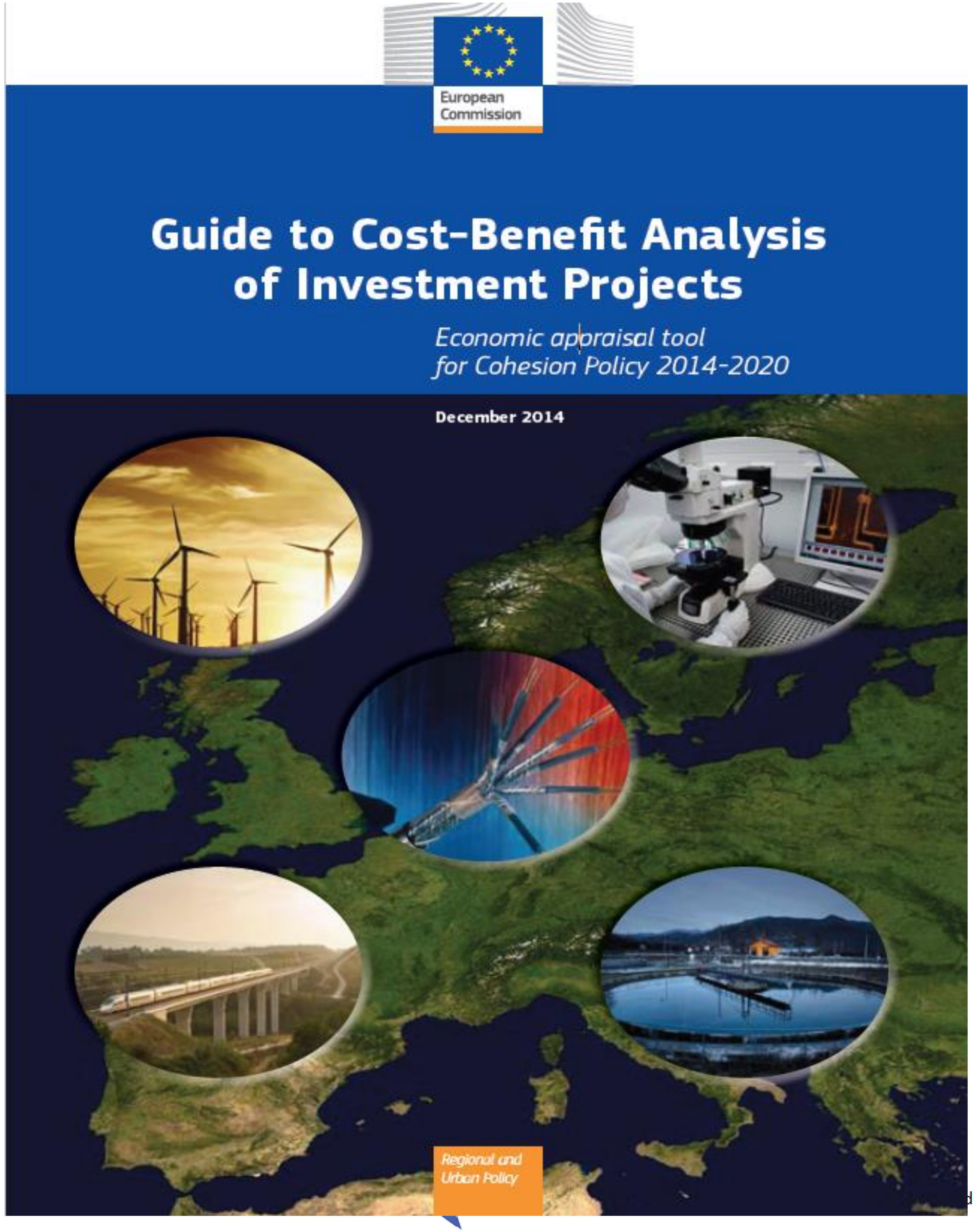
- **A METHOD FOR DETERMINING SOCIAL COSTS AND BENEFITS**
- It is a policy assessment method that quantifies the value of policy consequences (usually called ***impacts***) in monetary terms to **all** members of society
- A CBA calculates net social benefits (*NSB*) for each policy alternative: net social benefits equal social benefits (*B*) minus social costs (*C*): ***NSB=B - C***

About Cost Benefit Analysis

Public policy participants disagree about specific issues in CBA, such as:

- how to monetize costs and benefits
- what impacts are (especially over time)
- whether an impact is a cost or a benefit
- how to make trade-offs between the present and the future


Directorate General
European Programmes,
Coordination and Development
REPUBLIC OF CYPRUS
Manual for Pre-Selection and Appraisal
of Public Investment Projects
European Commission
WORLD BANK GROUP
May 2016


European Commission
Guide to Cost-Benefit Analysis
of Investment Projects
Economic appraisal tool
for Cohesion Policy 2014-2020
December 2014
Regional and
Urban Policy

Types of CBA:

- *Ex ante* CBA – conducted prior to the policy intervention. Useful to show whether resources should be used on a program or project
- *Ex post* CBA – conducted at the end of the policy intervention. Provides information about the particular class of intervention
- *In medias res* CBA- conducted during the policy intervention
- Comparative CBA – compares the ex *ante* predictions to ex *post* results for the same project (very few of these comparisons have been conducted because the clients of ex *post* analyses are different from the clients of ex *ante* analyses)

Project-specific Decision Making

- ***Ex ante*** analysis is most useful for making resource allocation decisions
- ***In medias res*** CBA analysis can also be used for this purpose, but ex post analysis is too late to divert resources to alternative uses.

<u>Learning</u> About the Value of the Specific Project

- ***Ex post*** analysis is the most useful for looking at the efficiency of a particular project, then in medias res, then ex ante
- The reason is that more is learned about the actual impacts of the project as time goes by

Learning About the Potential Benefits of Similar Projects

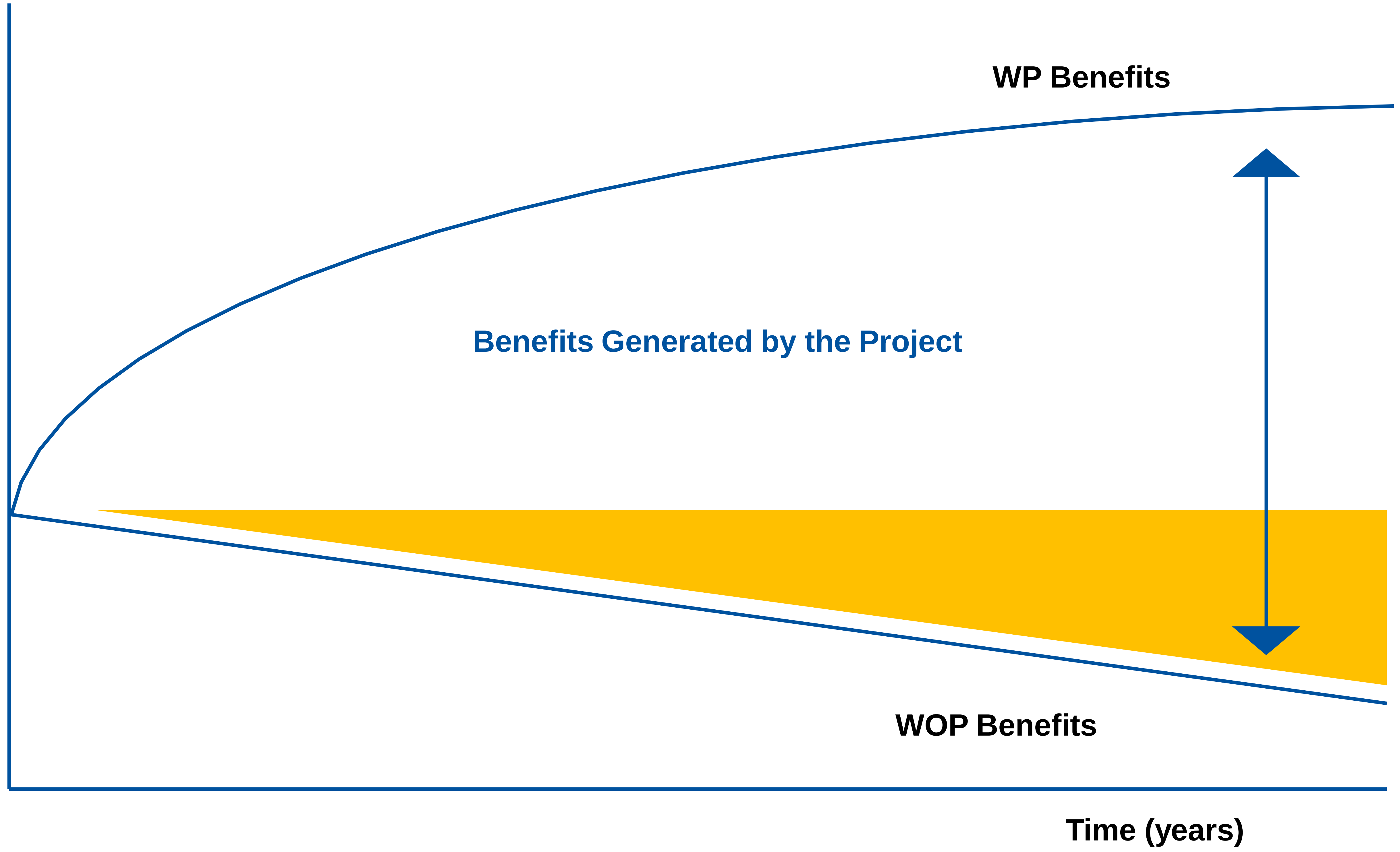
- ***Ex post*** analysis also provides information about the probable costs and benefits of similar future interventions
- The amount of learning depends on the representativeness of the particular project, i.e., how generalizable the project it is to other projects or large-scale projects

Learning About the Efficacy of CBA

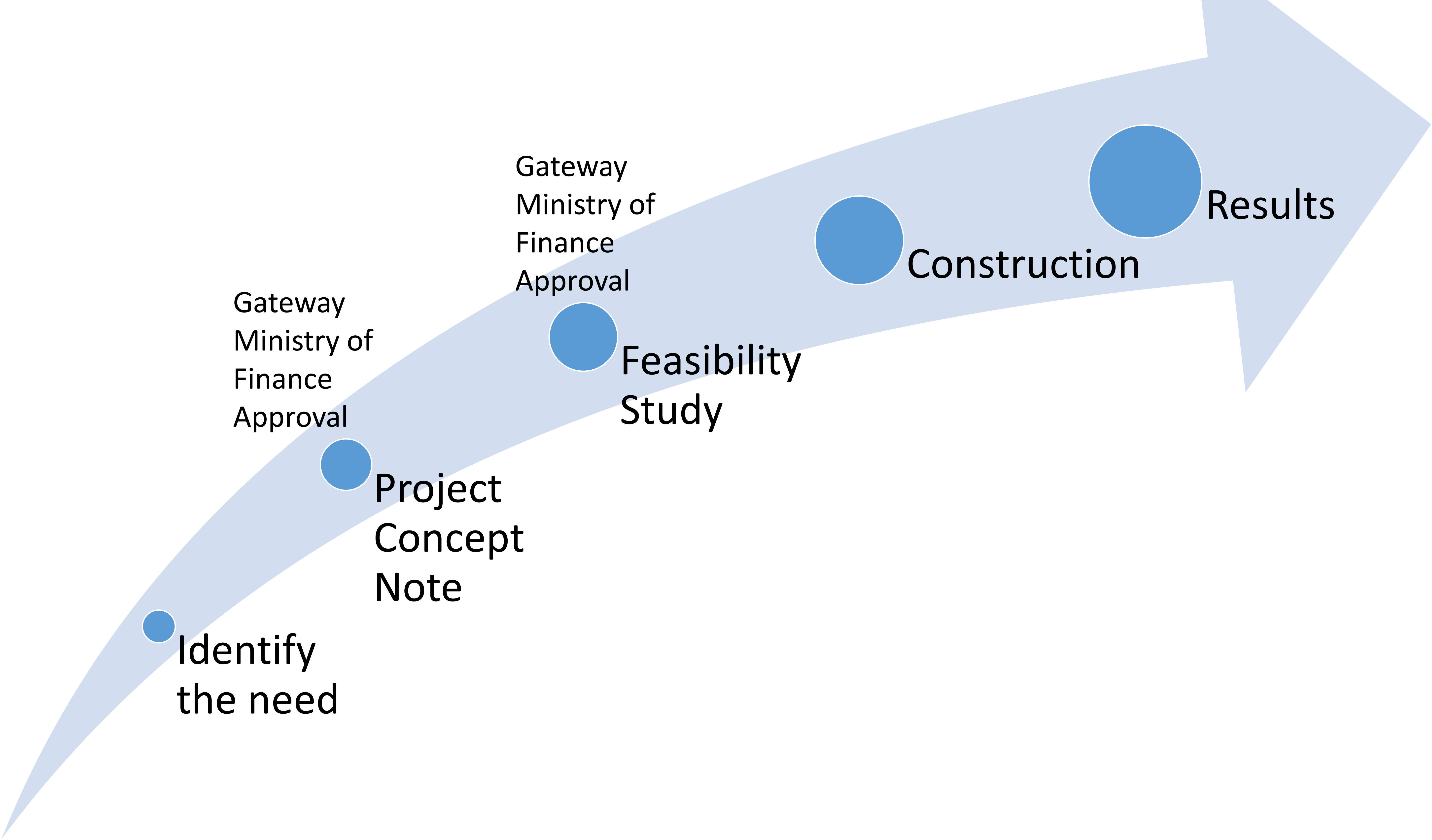
- A fourth type of analysis compares *ex ante* analyses to either *in medias res* or *ex post* analyses
- These comparisons provide information about the accuracy of *ex ante* CBAs
- These comparisons also help our understanding of prediction error

Are there better ways to achieve this objective?

Are there better uses for these resources?


WP Benefits
Benefits Generated by the Project
WOP Benefits
Time (years)

Projects > €5.000.0000



Steps in Project Appraisal

9 Identify the preferred project alternative - Recommendation

8 Assess affordability and sustainability

7 Analyse risks and plan for their management

6 Calculate NPV for all project alternatives

5 Value economic benefits and costs

4 Identify relevant benefits and costs

3 Demonstrate the demand for the services

2 Identify and choose project alternatives

1 Define the project objectives and scope

Preliminary Skills

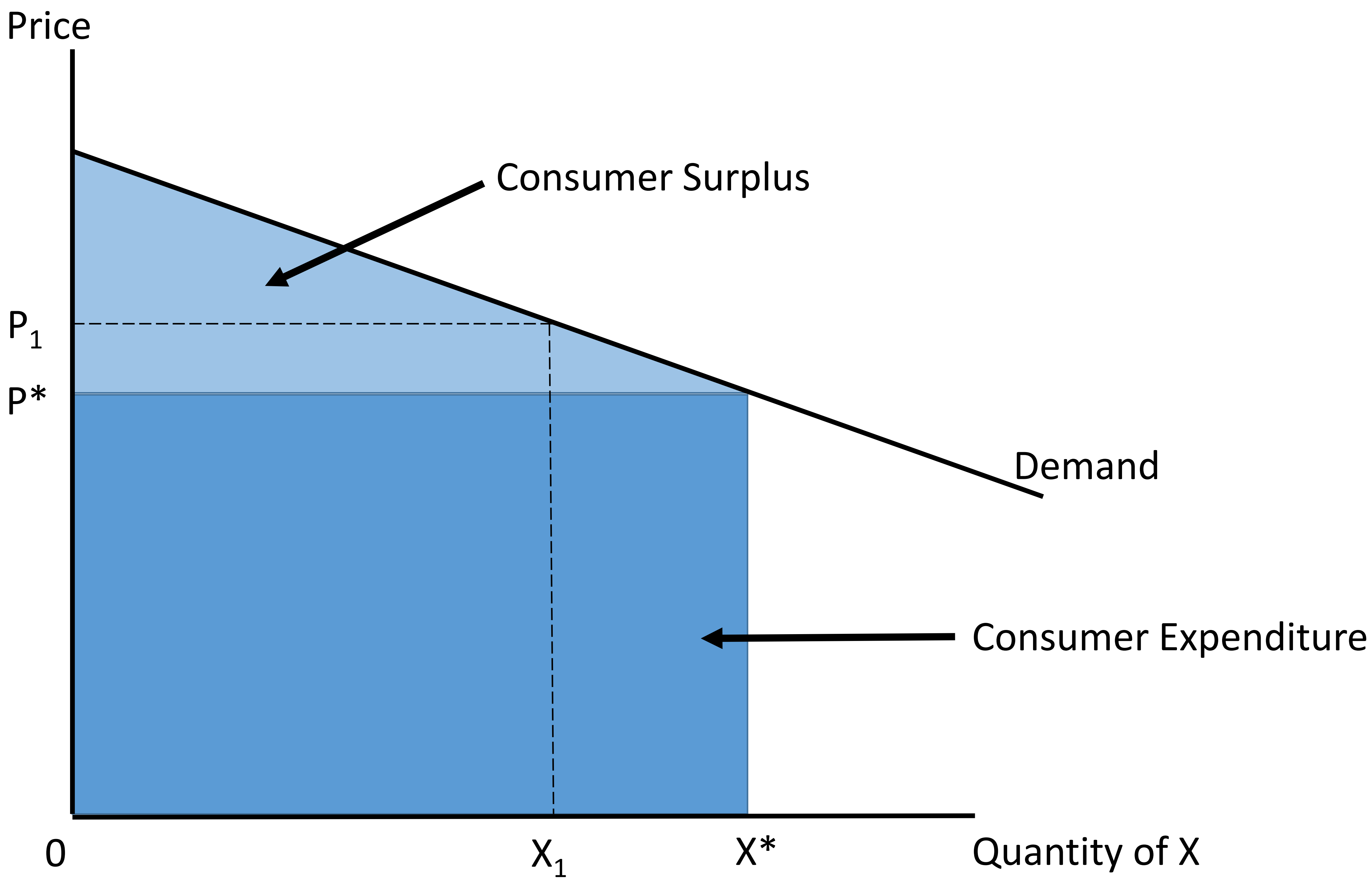
Preliminary Skills

Theoretical Foundations of Cost Benefit Analysis

Demand Curves

- Downward slope
- They indicate willingness to pay (WTP) for various quantities of the good
- Consumer surplus can be derived from a demand curve. The area under the market demand curve (i.e., the horizontal sum of the individual demand curves) is society's WTP for good X
- This area, WTP, is defined as the gross benefits of society for consuming X* amount of the good.

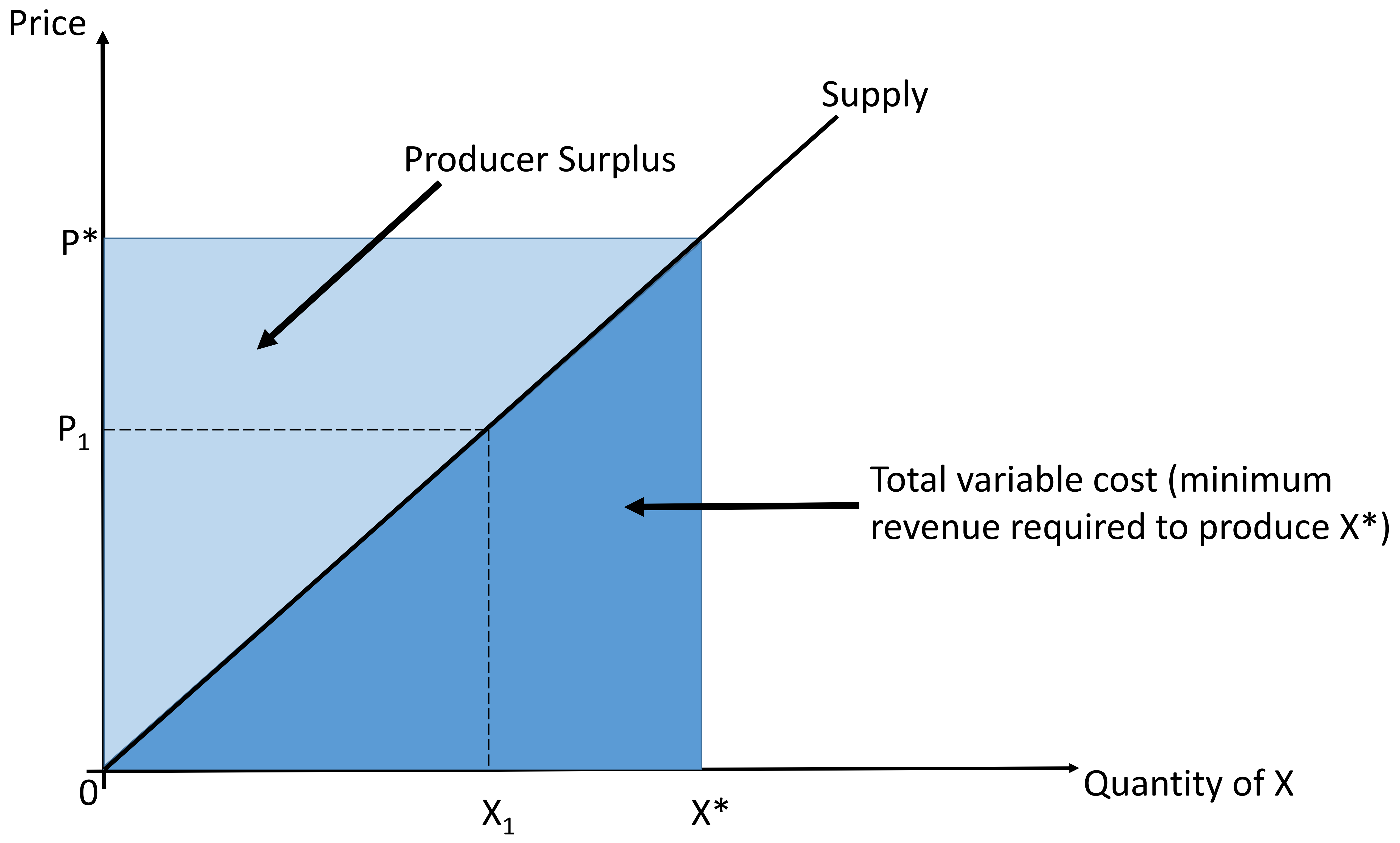
Demand Curve



Supply Curves

- The upward sloping segment of a firm's marginal cost curve above its ***average variable cost*** curve is the supply curve (below the average variable cost, the firm would shut down)
- The marginal cost curve is the additional opportunity cost to produce each additional unit of the good
- The area under the curve represents the ***total variable cost*** of producing a given amount of the good

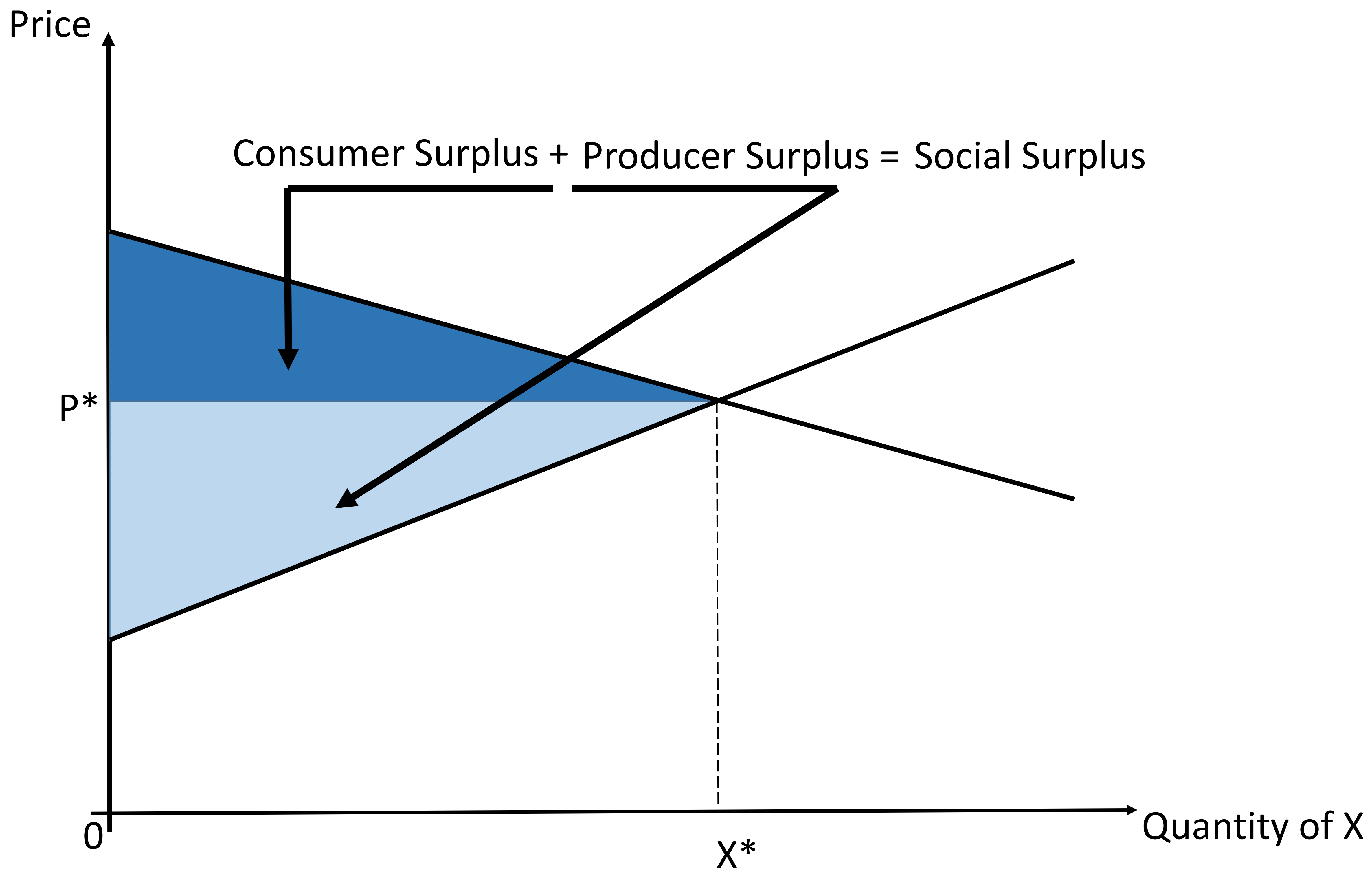
Supply Curve



Social Surplus

- Consumer surplus plus the producer surplus equals **social surplus**
- Social surplus is the area between the demand and supply curves to the left of the equilibrium point
- In perfect competition, the equilibrium output X* (where the supply and demand curves intersect) maximizes the social surplus.

Social Surplus

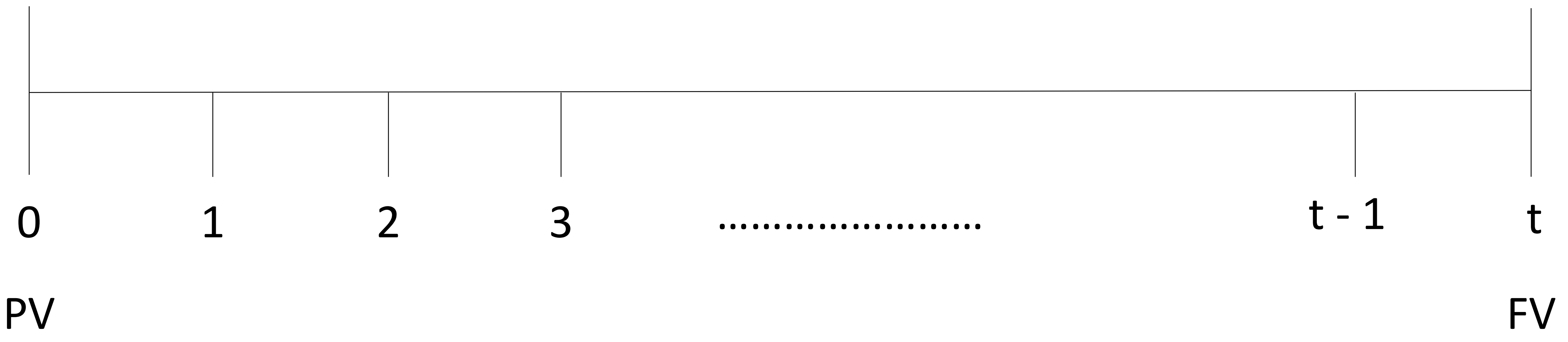


Preliminary Skills – Time Value of Money

- “Virtually every decision involves time and uncertainty”
  - ➔Time
  - ➔Uncertainty
- We will focus on *Time* and we will assume that there is no uncertainty (for now)

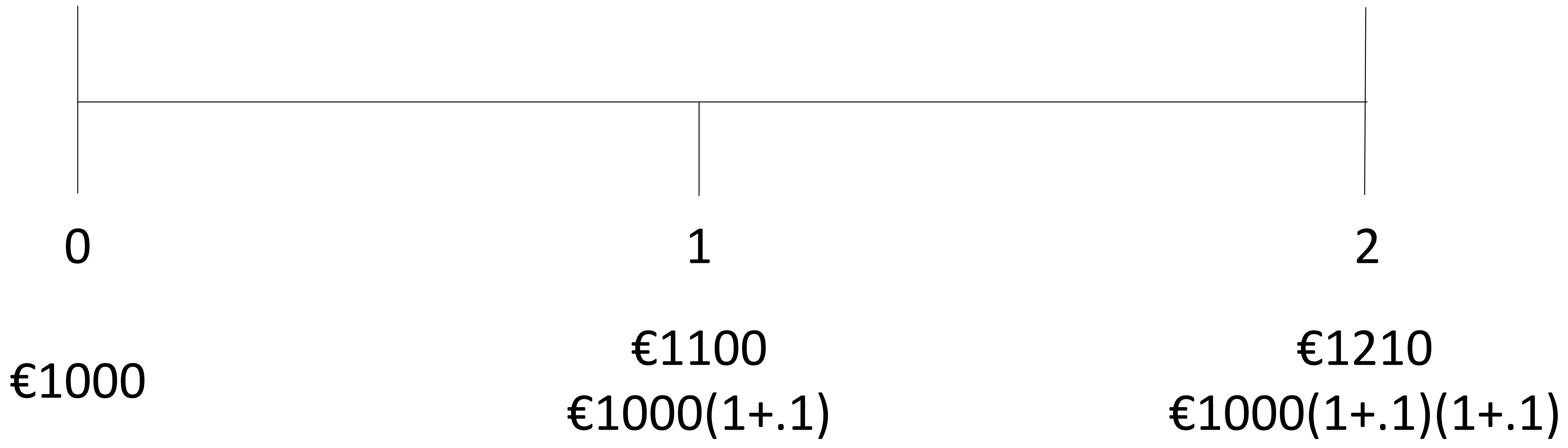
Preliminary Skills – Time Value of Money

- PV = Present Value (€)
- FV = Future Value (€)
- t = # of Periods (#)
- r = Interest Rate (%)



Preliminary Skills – Time Value of Money - FV

- €1 today has a different value of €1 tomorrow
- $\mathrm{FV} = PV(1+r)^{t}$
- Example: What is the FV of €1000, 2 years from now (r = 10%)



Let’s Practice!!!

Preliminary Skills – Time Value of Money - FV

- Invest €500 in the bank at r = 7%. How much will you have at the end of 10 years?

- What is the FV of investing €1000 @ r = 10% versus r= 5% for 100 years?

- Peter Minuit "bought" Manhattan island from Native Americans for $24 in 1626. Suppose Native Americans could have earned 6% on that amount all these years. How much would they have today?

Preliminary Skills – Effective Interest

- The actual rate of interest during the investment period.
- $(1+\frac{r}{m})^{t\,*m}$
- What is the FV of €500 invested for 5 years @ r = 8% per annum convertible quarterly?
  - $500(1+\frac{.08}{4})^{4*5} = 742.97$
    - $500(1+.08)^{5} = 734.66$

  - $500(1+.02)^{20} = 742.97$
  - $500(1+\frac{.08}{4})^{4*5} = 500(1+.02)^{20}$

Preliminary Skills – Present Value

- Value of future €, today.
- $PV = \frac{FV}{(1+r)^t}$
- Value of €1 one year from now, today (r = 5%)
  - $PV = \frac{1}{(1+.05)^1} = €0.952$

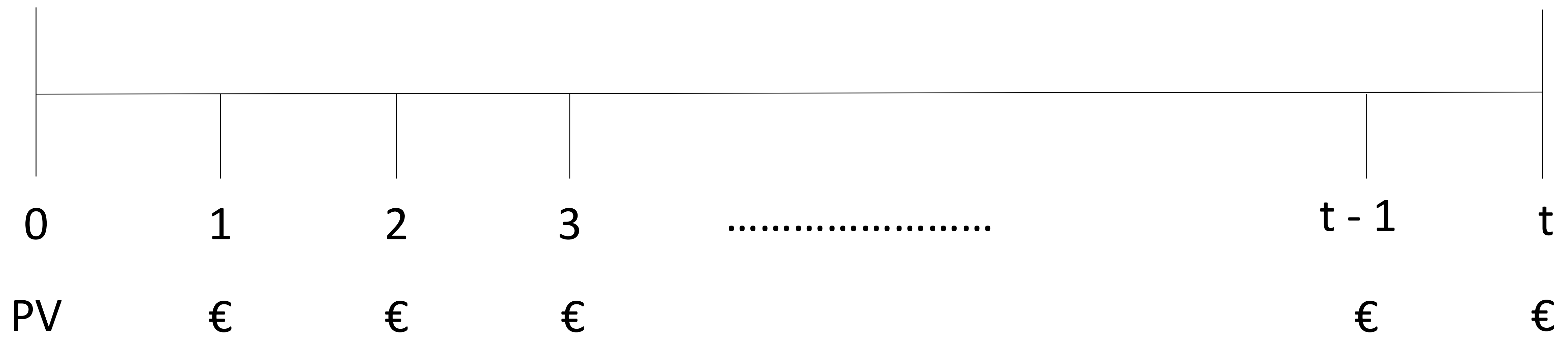
Let’s Practice!!!

Rule of 72

- Time needed to double €.
- $FV = PV(1+r)^t$
- $1(1+r)^t = 2$
- Proof

Preliminary Skills – Time Value of Money - Annuity

- Annuity is a series of payments made at equal intervals in time
  - i.e. multiple payments



Preliminary Skills – Time Value of Money – Annuity - Examples

- What will be the value of your portfolio at retirement if you deposit €10,000 every year in a pension fund? You plan to retire in 40 years and expect to earn 8% on your portfolio.

- Suppose you want to guarantee yourself €500,000 when you retire 25 years from now. How much must you invest each year, if the interest rate is 8%.

- How much money do you need in the bank today so that you can spend €10,000 every year for the next 25 years starting at the end of this year? Suppose r = 5%

Preliminary Skills – Time Value of Money – Annuity – Present Value

- How much money do you need in the bank today so that you can spend €10,000 every year for the next 25 years starting at the end of this year? Suppose r = 5%.

- $PV = \frac{€10{,}000}{(1+r)} + \frac{€10{,}000}{(1+r)^2} + \cdots + \frac{€10{,}000}{(1+r)^t}$

Decision Tools - Net Present Value

- NPV measures how much cheaper (or more expensive, if the difference were negative) is to invest in the start-up than in the alternative opportunity
- $NPV = \sum_{t=0}^{t} \frac{(B_t - C_t)}{(1+r)^t}$
- NPV > 0

Decision Tools - Net Present Value – Example (1)

- Suppose the forecast, with an initial investment of €250,000, will generate net cash flows of €155,000 one year from now, €215,000 two years from now and €350,000 three years from now
- $PV(r) = \frac{€155{,}000}{(1+r)} + \frac{€215{,}000}{(1+r)^2} + \frac{€350{,}000}{(1+r)^3}$
- $NPV(r) = PV(r) - €250{,}000$
- r = 15%
- $PV(.15) = \frac{€155{,}000}{(1+.15)} + \frac{€215{,}000}{(1+.15)^2} + \frac{€350{,}000}{(1+.15)^3} = €527{,}484.18$
- $PV = €134{,}782.61 + €162{,}570.89 + €230{,}130.68 = €527{,}484.18$

Decision Tools - Net Present Value – Example (2)

- Suppose the forecast, with an initial investment of €250,000, will generate net cash flows of €155,000 one year from now, €215,000 two years from now and €350,000 three years from now
- $FV(1) = (1 + .15) * €134{,}782.61 = €155{,}000$
- $FV(2) = (1 + .15) * €162{,}570.89 = €215{,}000$
- $FV(3) = (1 + .15) * €230{,}130.68 = €350{,}000$
- $NPV(r) = PV(r) - \ C_0$
- $NPV = €527{,}484.18 - \ €250{,}000 = €277{,}484.18$

Decision Tools - Net Present Value - Example

Year	Cash Flow	Years to Discount:n	PV @ year 0
0	-€1,000	0	-€1,000
1	€1,320	1	€1,200
NPV = €200			

- $\frac{1{,}320}{(1+.10)^1} = 1{,}200$
- $NPV = \sum_{t=0}^{t} \frac{(B_t - C_t)}{(1+r)^t} = -1000 + 1200 = 200$
- ***<u>Net</u>*** comes from the fact that we have to subtract the initial investment

Let’s Practice!!!

Decision Tools – Internal Rate of Return (IRR)

- Book definition: IRR is the interest rate that sets NPV = 0
- $IRR = \sum_{t=0}^{t} \frac{(B_t - C_t)}{(1+r)^t} = 0$
- But practically what is it?

Decision Tools – Internal Rate of Return (IRR)

- $IRR = \sum_{t=0}^{t} \frac{(B_t - C_t)}{(1+r)^t} = 0$
- $€0 = -€250{,}000 + \frac{€155{,}000}{(1+r)} + \frac{€215{,}000}{(1+r)^2} + \frac{€350{,}000}{(1+r)^3}$
- $€250{,}000 = \frac{€155{,}000}{(1+r)} + \frac{€215{,}000}{(1+r)^2} + \frac{€350{,}000}{(1+r)^3}$
- IRR = 0.6528
- $€250{,}000 = €93{,}779.63 + €78{,}703.14 + €77{,}517.27 = PV(.6528)$
- IRR > Discount rate

Let’s Practice!!!

Decision Tools – Internal Rate of Return (IRR) What is it?

- It is the annualized effective compound rate of return !!!

Or put simply

- Compound Annual Return On Investment (Annualized ROI)

Decision Tools –IRR Issues (1)

- Multiple IRRs

Year	Cash Flow €
0	-100
1	230
2	-132
IRR =	

$$-100 + \frac{230}{(1+r)^1} + \frac{-132}{(1+r)^2} = 0$$

Decision Tools –IRR Issues (2)

- No IRR

Year	Cash Flow €
0	5
1	-4
2	-4
3	-4
4	-4
5	17
IRR =	

Decision Tools –IRR Issues (3)

- Short term bias (favors short term projects)

Year	Project A	Project B
0	-2000	-2000
1	400	2000
2	-2400	625
IRR		
NPV@4%		
NPV@20%		
NPV@11%		

Decision Tools –IRR Issues (4)

- Small Investment Bias

Year	Project A	Project B
0	-5000	-50000
1	7500	62500
IRR		
NPV@4%		
NPV@30%		
NPV@22%		

Decision Tools – Benefit Cost Ratio (BCR)

- The benefit-cost ratio (BCR) is another way of expressing the balance between the present value of benefits and the present value of costs:
- $BCR = \dfrac{sum\ of\ present\ values\ of\ benefits\ (cash\ inflows)}{sum\ of\ present\ values\ of\ costs\ (cash\ outflows)}$
- BCR > 1

Statistics

- «There are 3 kinds of lies. Lies, dump lies and Statistics»
- How to lie with Statistics
- In God we trust. All others must bring data

Can I trust my data?

CERN

First results

[edit]

In a March 2011 analysis of their data, scientists of the OPERA collaboration found evidence that neutrinos they produced at CERN in Geneva and recorded at the OPERA detector at Gran Sasso, Italy, had traveled faster than light. The neutrinos were calculated to have arrived approximately 60.7 nanoseconds (60.7 billionths of a second) sooner than light would have if traversing the same distance in a vacuum. After six months of cross checking, on September 23, 2011, the researchers announced that neutrinos had been observed traveling at faster-than-light speed.[8] Similar results were obtained using higher-energy (28 GeV) neutrinos, which were observed to check if neutrinos' velocity depended on their energy. The particles were measured arriving at the detector faster than light by approximately one part per 40,000, with a 0.2-in-a-million chance of being wrong, if the error were distributed as a bell curve (significance of six sigma). This measure included estimates for both errors in measuring and errors from the statistical procedure used. It is, however, a measure of precision, not accuracy, which could be influenced by elements such as incorrect computations or wrong readouts of instruments.[9][10] For particle physics experiments involving collision data, the standard for a discovery announcement is a five-sigma error limit, looser than the observed six-sigma limit.[11]

Ὁ Φιλελεύθερος

10:52 Τετάρτη
21 Μαρτίου 2012
www.philenews.com

Ειδήσεις SentraGoal Χρήσιμα Going out Staying in Περιοδικά Αρχείο «Φ» Αγγελίες

Celebrities | Life | Συνταγές | Tv Οδηγός | Ζώδια

Πέμπτη, 23 Φεβρουαρίου 2012 2:31 μμ

Ο Αϊνστάιν ανακουφίζεται

Πιθανό λάθος στο πείραμα που κατέγραψε υπέρβαση της ταχύτητας του φωτός

Το φως φαίνεται ότι διατηρεί το παγκόσμιο ρεκόρ ταχύτητας.

Γενεύη: Είναι πολύ πιθανό ότι ο Αϊνστάιν δεν θα κατέβει από το βάθρο του, όχι ακόμα τουλάχιστον, καθώς νέα στοιχεία δείχνουν ότι μάλλον σε τεχνικό σφάλμα οφείλεται η απρόσμενη μέτρηση πως το υποατομικό σωματίδιο νετρίνο ταξιδεύει πιο γρήγορα από το φως.

Τη σχετική ανακοίνωση είχαν κάνει πέρυσι οι ερευνητές του ευρωπαϊκού πειράματος OPERA/CERN και έχει έκτοτε προκαλέσει έξαψη στη διεθνή επιστημονική κοινότητα. Όμως και η νέα εκτίμηση περί τεχνικού λάθους δεν είναι οριστική και θα πρέπει να επιβεβαιωθεί στο μέλλον.

Can I trust my data?

Preliminary Skills – Statistics – Data Cleaning

Top > Medicine, Health Care > Interesting NHS Statistics Reveal Data... >

Interesting NHS Statistics Reveal Data Errors in Care Records

Published: April 6, 2012. By BMJ-British Medical Journal
http://www.bma.org

In a letter published today on BMJ, authors from Imperial College London NHS Healthcare Trust stress the importance of accurately capturing and coding patient episodes.

The authors reviewed available data from HESonline, the national statistic warehouse of England of the care provided by the NHS.

Statistics found were interesting and surprising: on average, 1600 adults aged over 30 apparently attend outpatient child and adolescent psychiatry services in England each year. There has also been a steep increase in the number of adults attending outpatient paediatric services since 2003 which in 2009-10 stood at 20,000.

The authors joke that the amount of adults using paediatric services maybe part of an innovative exchange programme as results show that, apparently, the number of 0-19 year olds attending geriatric services has increased steadily with over 3000 attendances in 2009-10.

Further results which surprised the authors were the amount of male patients attending apparently female medical appointments. They found that many males were attending obstetrics, gynaecology and midwifery clinics: between 2009-10 there were over 17,000 male inpatient admissions to obstetric services, over 8000 to gynaecology and nearly 20,000 to midwifery.

The authors suggest that while these statistics reveal "some interesting service developments" and they "applaud innovation", they reflect some likely data errors.

The authors argue that this data will inform the decision making regarding how NHS services are commissioned. They conclude that clinicians should "all examine the data being submitted by and about our services for unintentional innovation".

Preliminary Skills – Statistics

Types of variables

Types of variables

- Numerical (quantitative): numerical values
  - Continuous: infinite number of values within a given range, often measured
  - Discrete (ordinal): specific set of numeric values that can be counted or enumerated, often counted
- Categorical / Nominal (qualitative): limited number of distinct categories
  - Ordinal: finite number of values within a given range, often measured

Preliminary Skills - Descriptive Statistics

Measures of Center

- Mean (numerical average)
- Median (midpoint)
- Mode (most frequent)

Preliminary Skills - Descriptive Statistics – Mean (arithmetic)

- $\bar{x} = \frac{\sum_i^n x_i}{n} = \frac{x_1+x_2+x_3+\cdots+x_n}{n}$
- μ ➔ population
- $\bar{x}$ ➔ sample

Preliminary Skills - Descriptive Statistics – Geometric Mean

- $\left(\prod_{i=1}^{n} x_i\right) = \sqrt[n]{x_1 * x_2 * \cdots * x_n}$

Preliminary Skills - Descriptive Statistics

Measures of Center

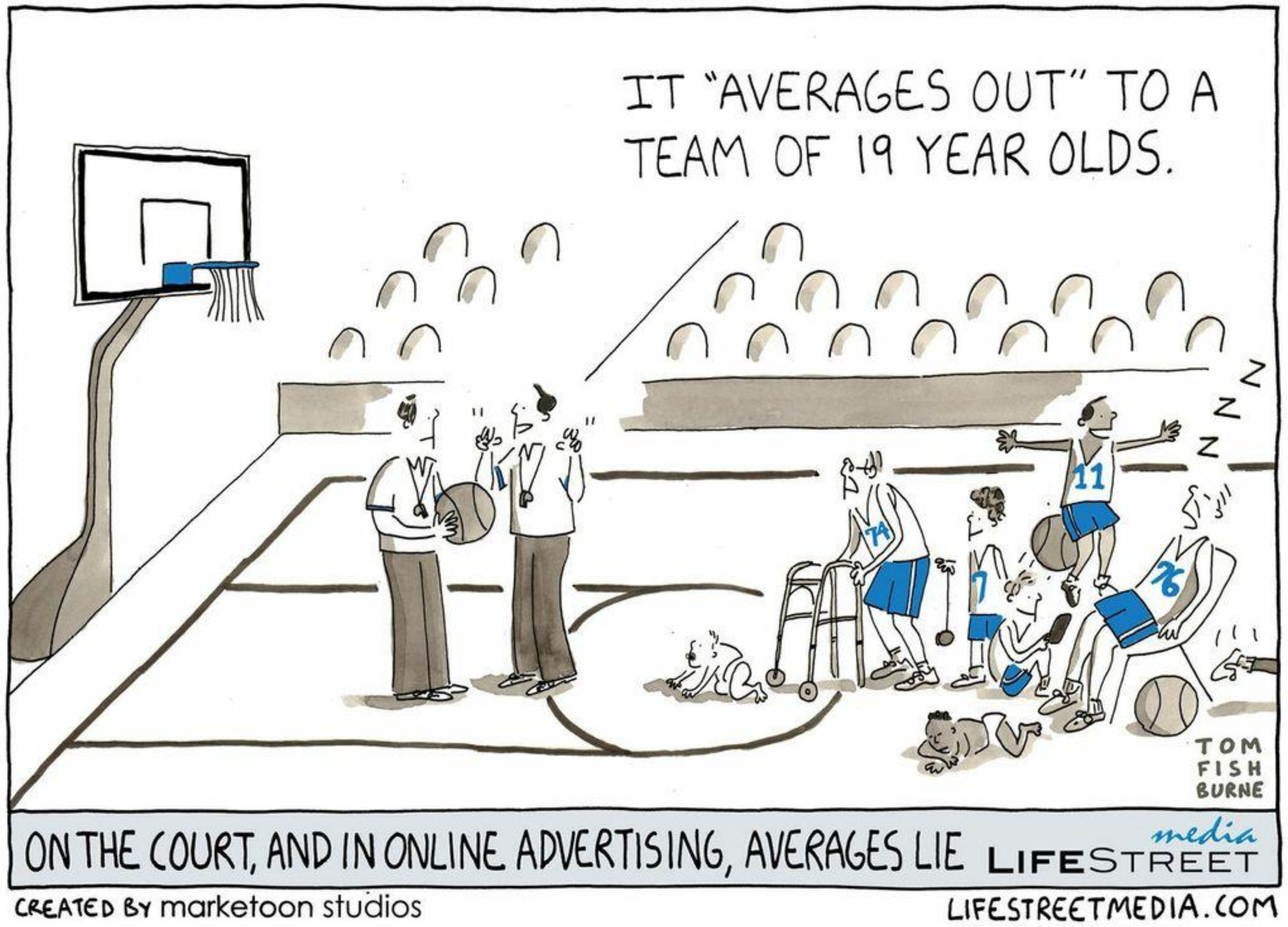
- Mean (numerical average)
- Median (midpoint)
- Mode (most frequent)

Preliminary Skills - Descriptive Statistics

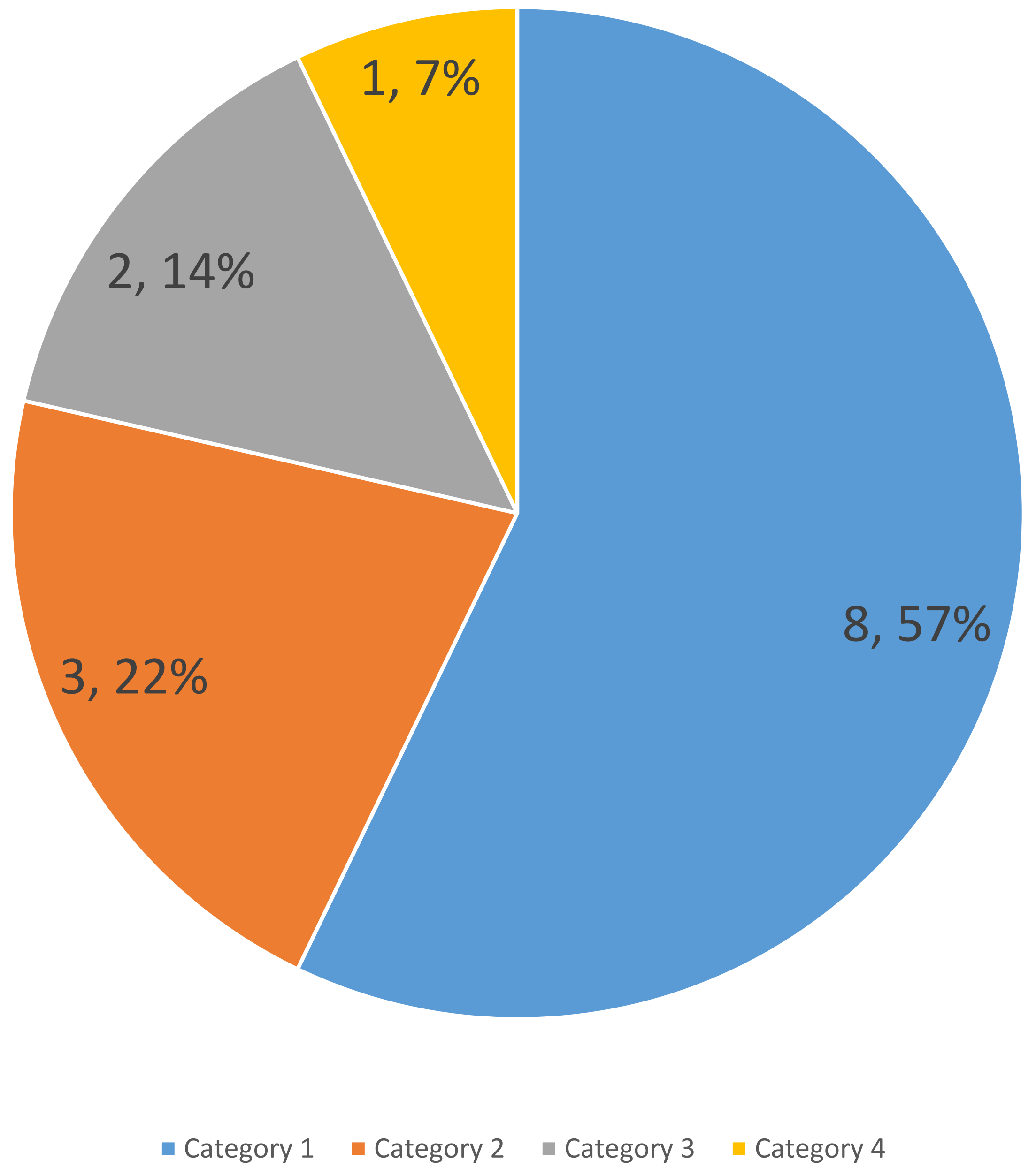
Measures of variation

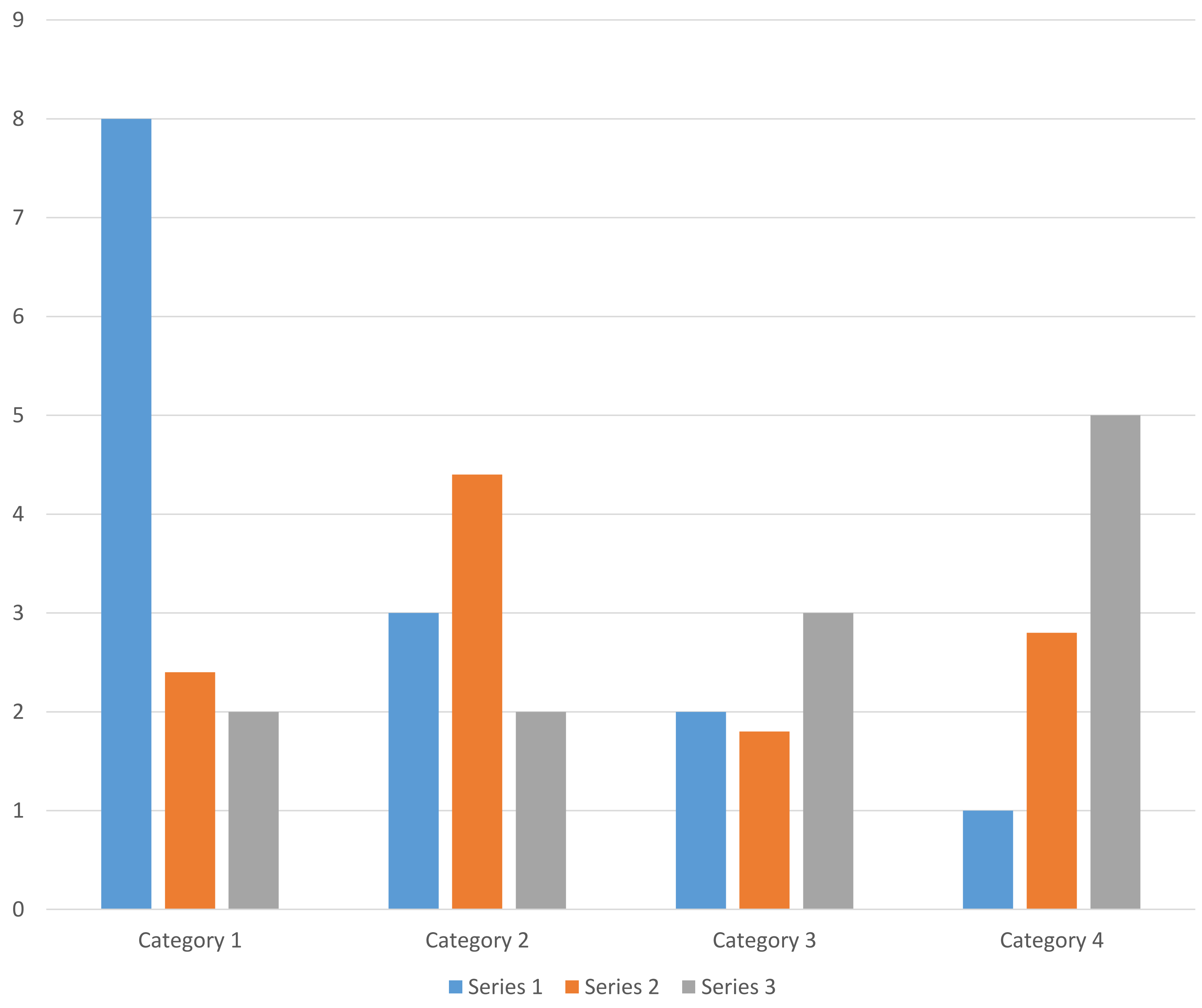
- Range (max – min)
- Percentiles and quartiles
- IQR
- Variance (average squared distance from the mean)
- Standard deviation ($\sqrt{variance}$)

Let’s Practice!!!

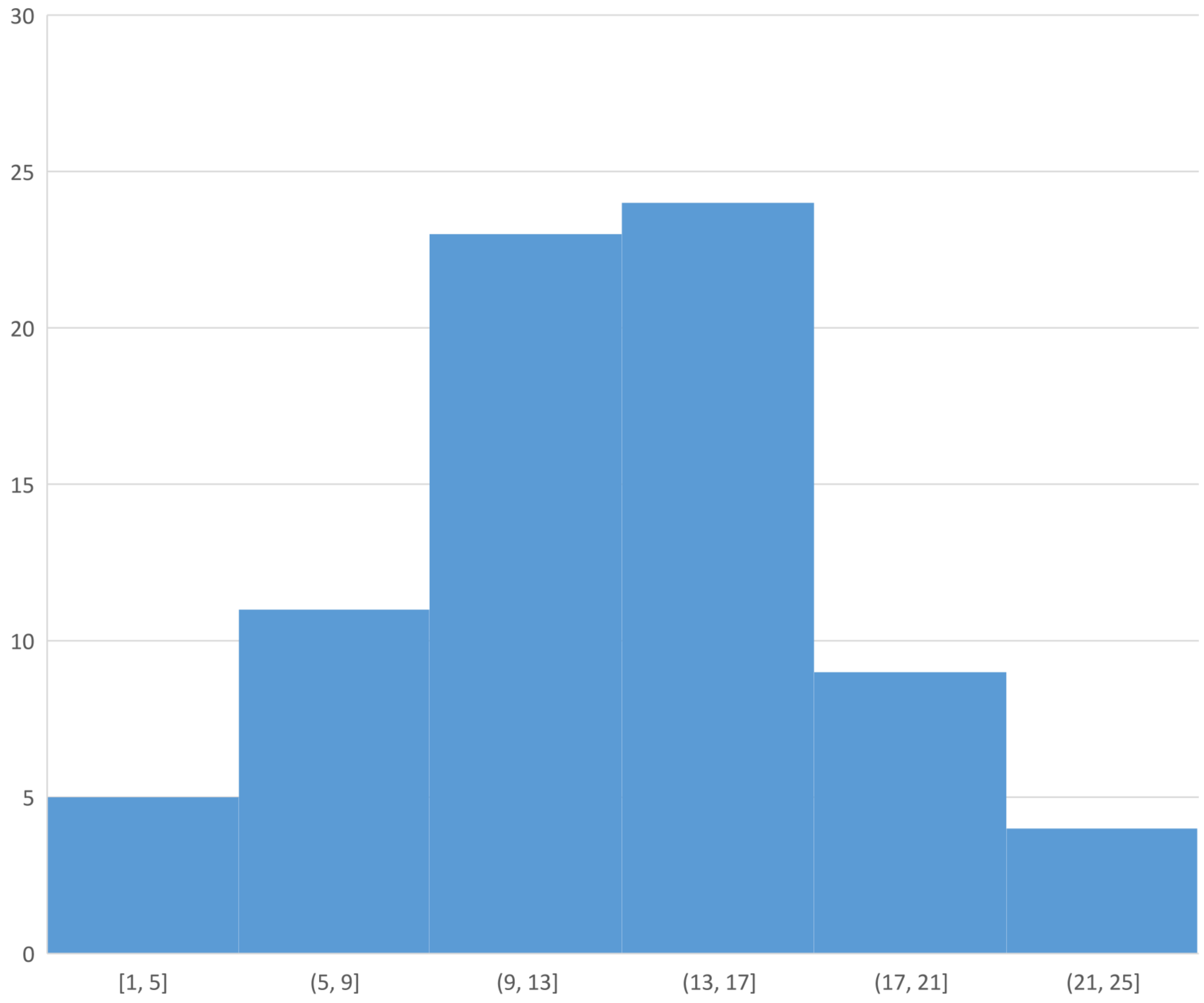

IT "AVERAGES OUT" TO A TEAM OF 19 YEAR OLDS.
11
74
7
76
TOM FISH BURNE
ON THE COURT, AND IN ONLINE ADVERTISING, AVERAGES LIE
LIFESTREET media
CREATED BY marketoon studios
LIFESTREETMEDIA.COM

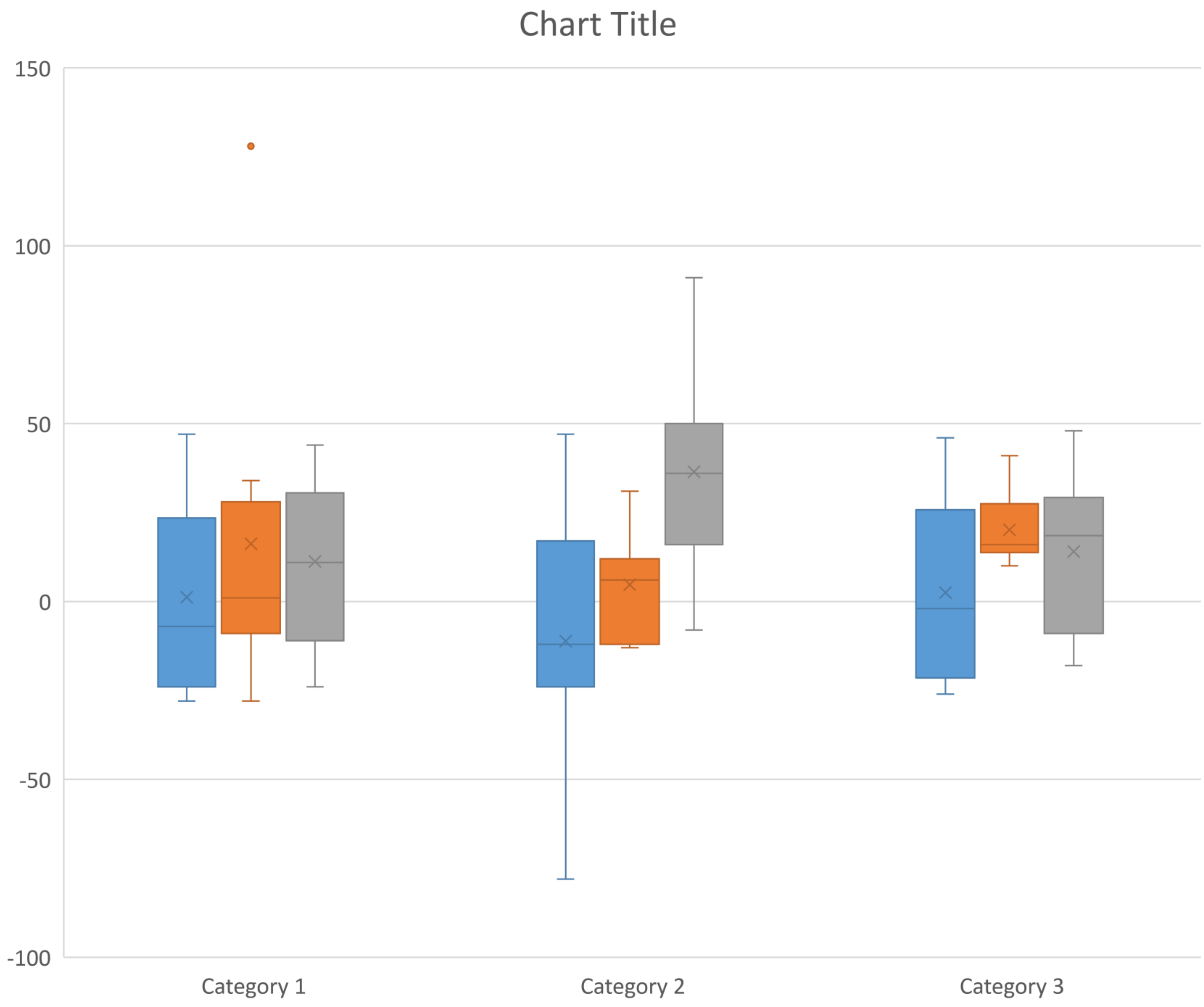
Graphs – Nominal variables



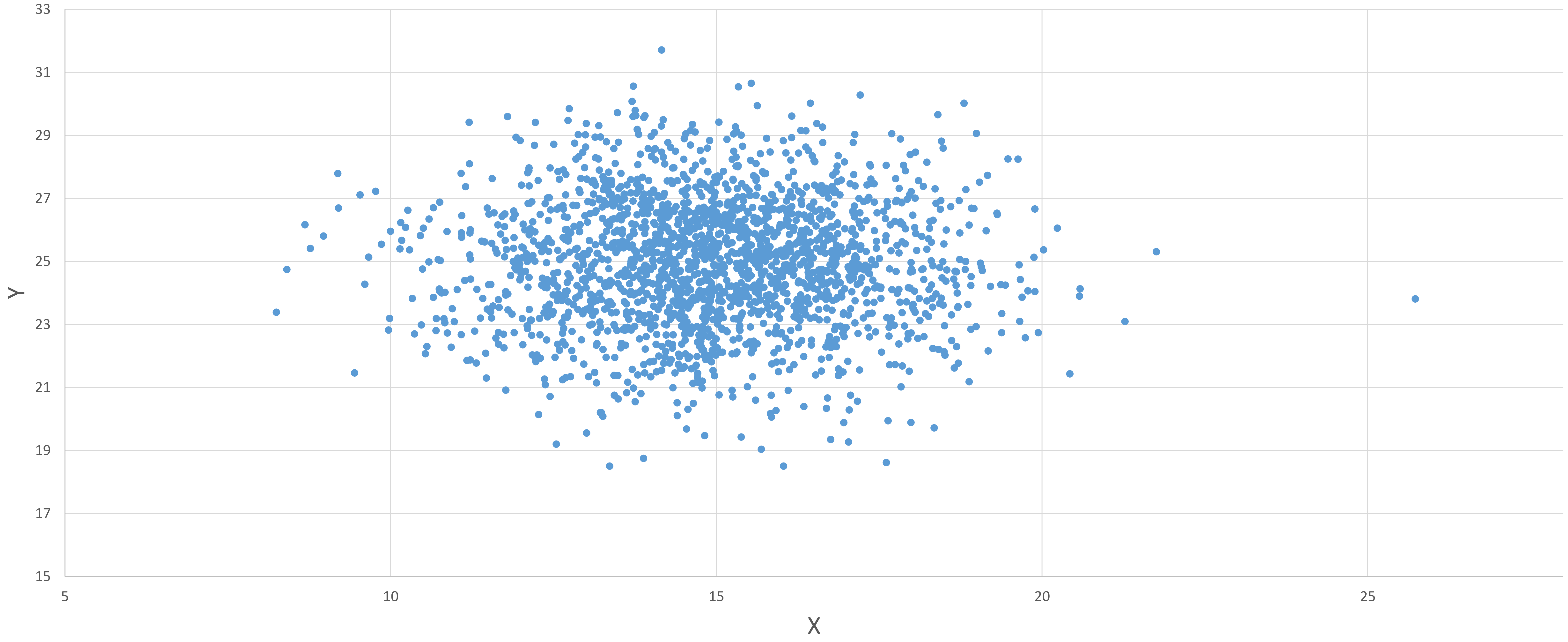


Graphs – Numerical variables

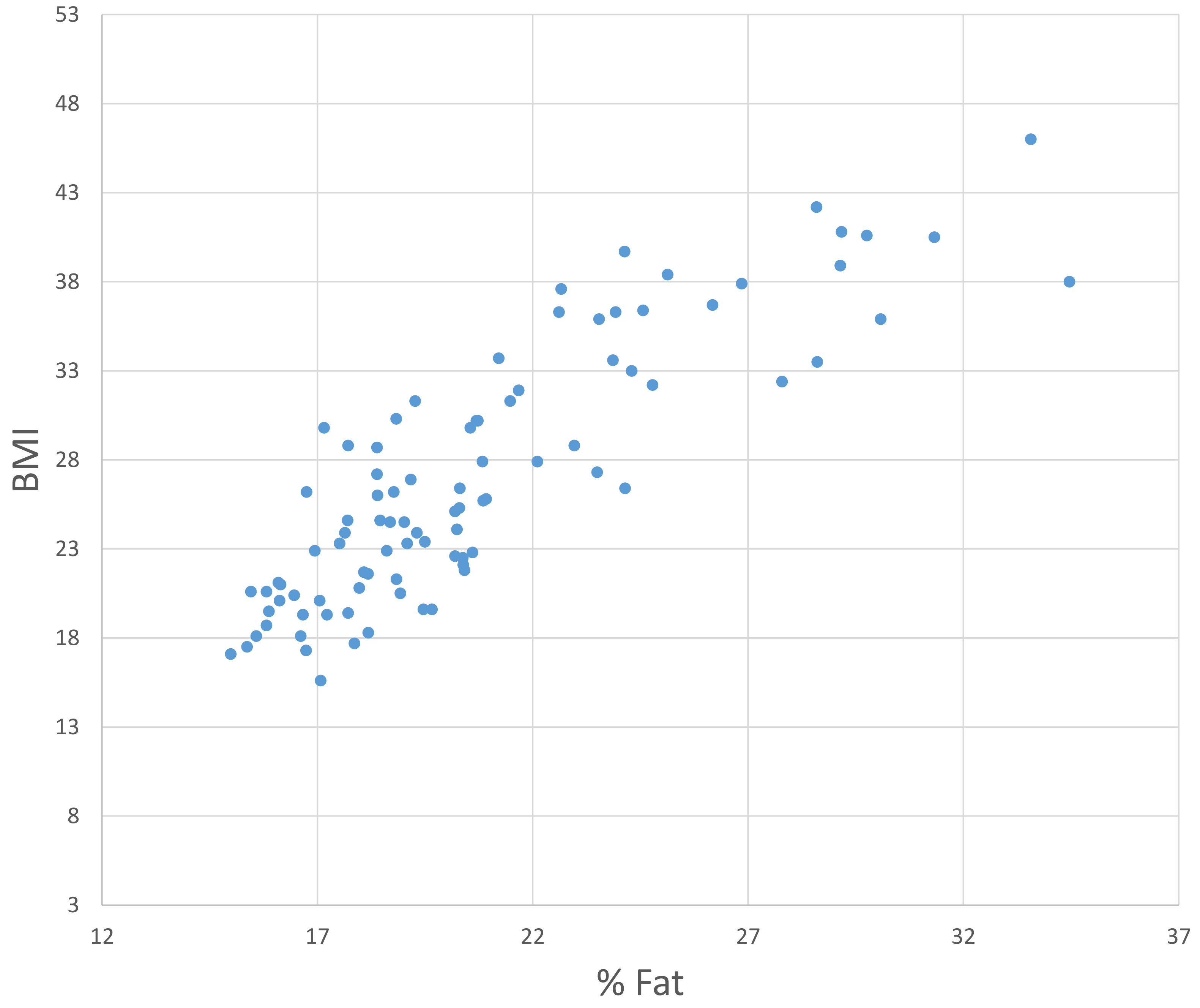


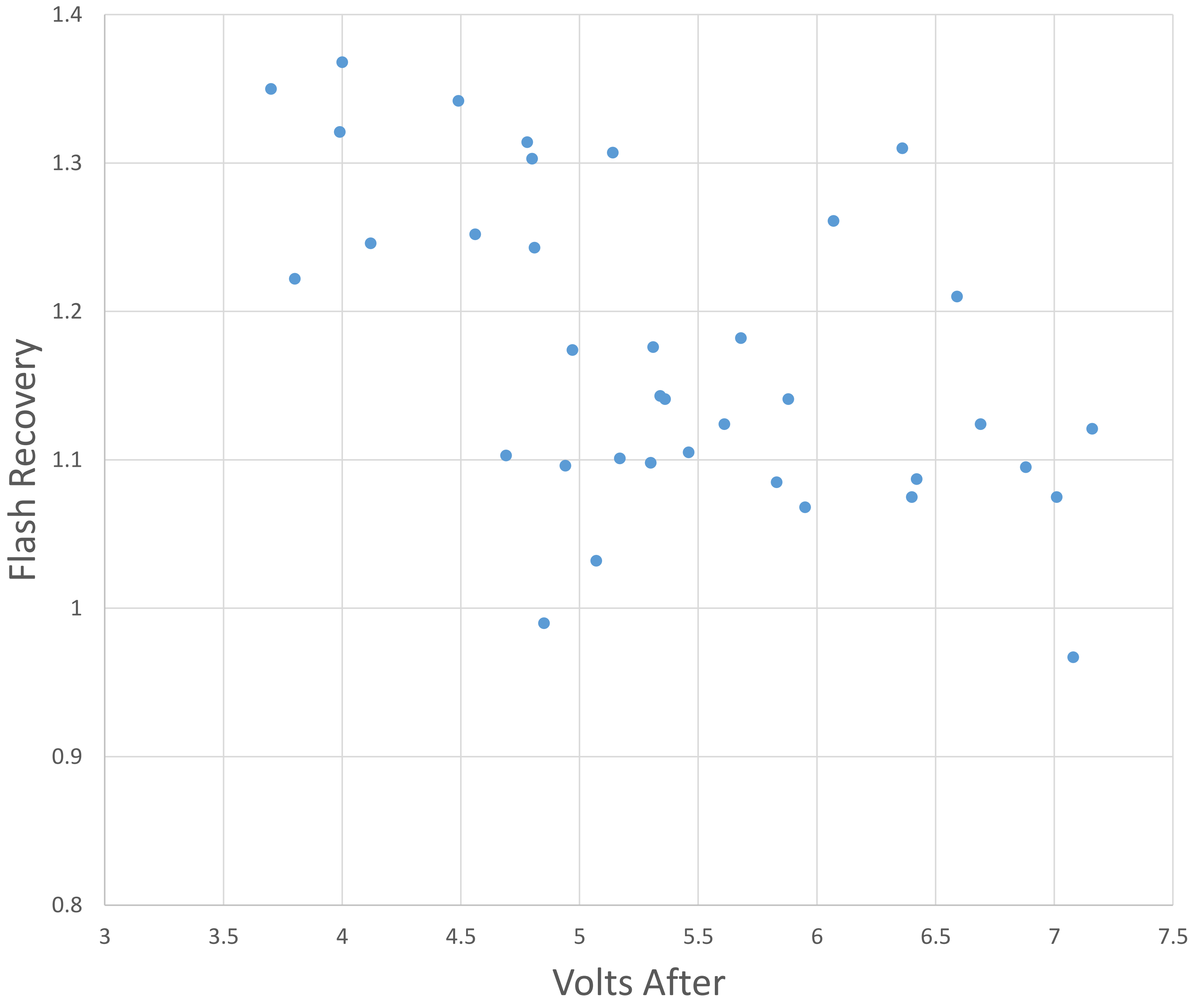


Graphs – Numerical Variables – Scatter Plot



Graphs – Numerical Variables – Scatter Plot





Preliminary Skills – Probability

- $P = \dfrac{outcome}{set\ of\ all\ possible\ outcomes}$
- P = 0 ➔ impossible
- P = 1 ➔ certain

- Combinations ($_nC_r$)
  - Given ***n*** distinct objects, any unordered subset of size ***r*** is called a combination

Preliminary Skills – Probability

- Question
- On a day, the probability of rainfall is 30% and it rained. Is the weather forecast correct or not?

Preliminary Skills – Expectation

- The expected value of a discrete random variable X, which we will denote E(X), is the probability-weighted average of the possible values of X, that is
- $E(X) = \sum(x * f(x))$
- Example
- A fair coin is tossed and you receive €10 or pay €10 according to whether Heads or Tails is observed.

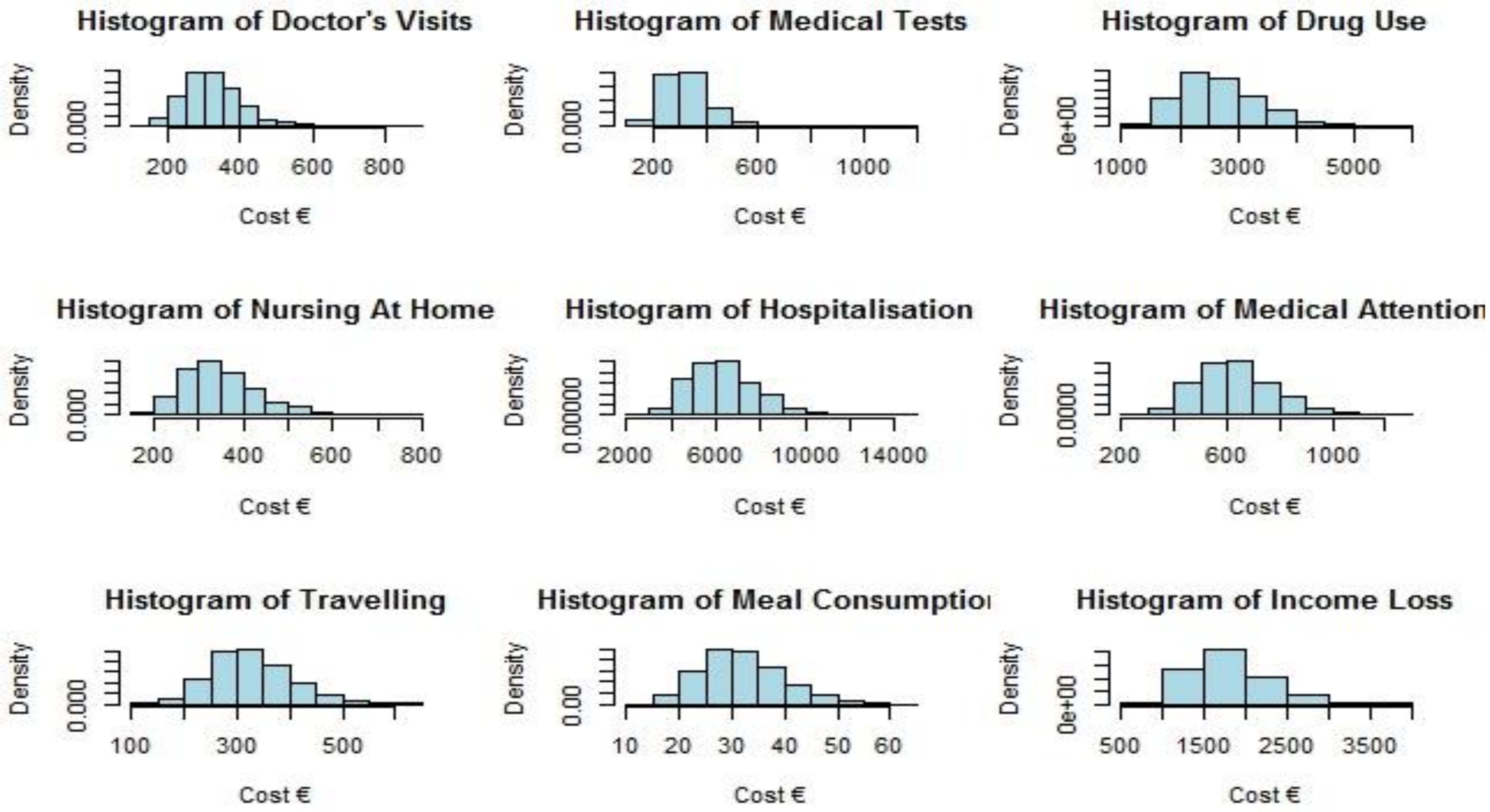
Preliminary Skills – Expectation

- Thus (example from the manual p. 61)

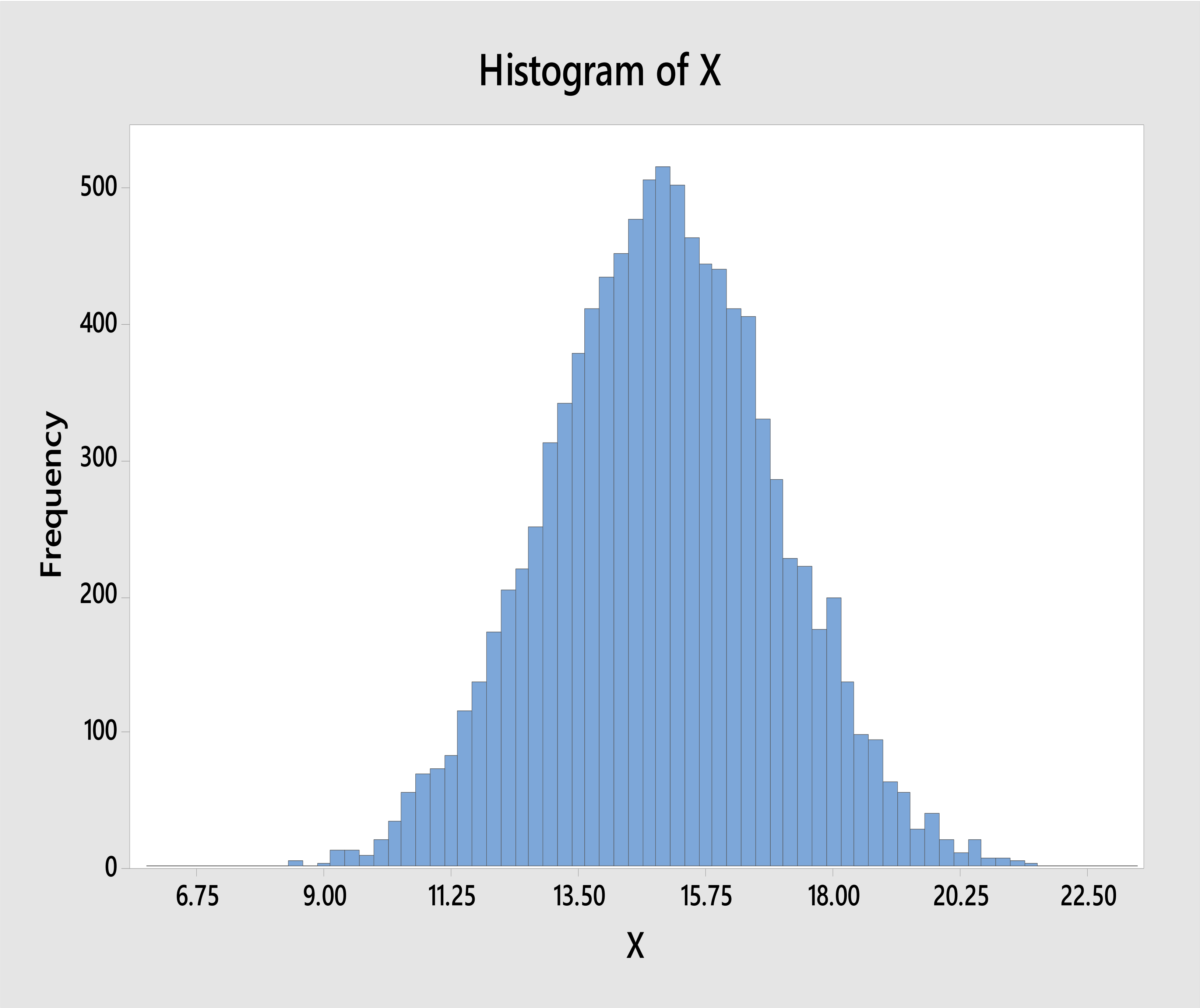
Scenario	Probability	NPV (€ million)
Worst	0.35	2
Base	0.5	7
Best	0.15	11

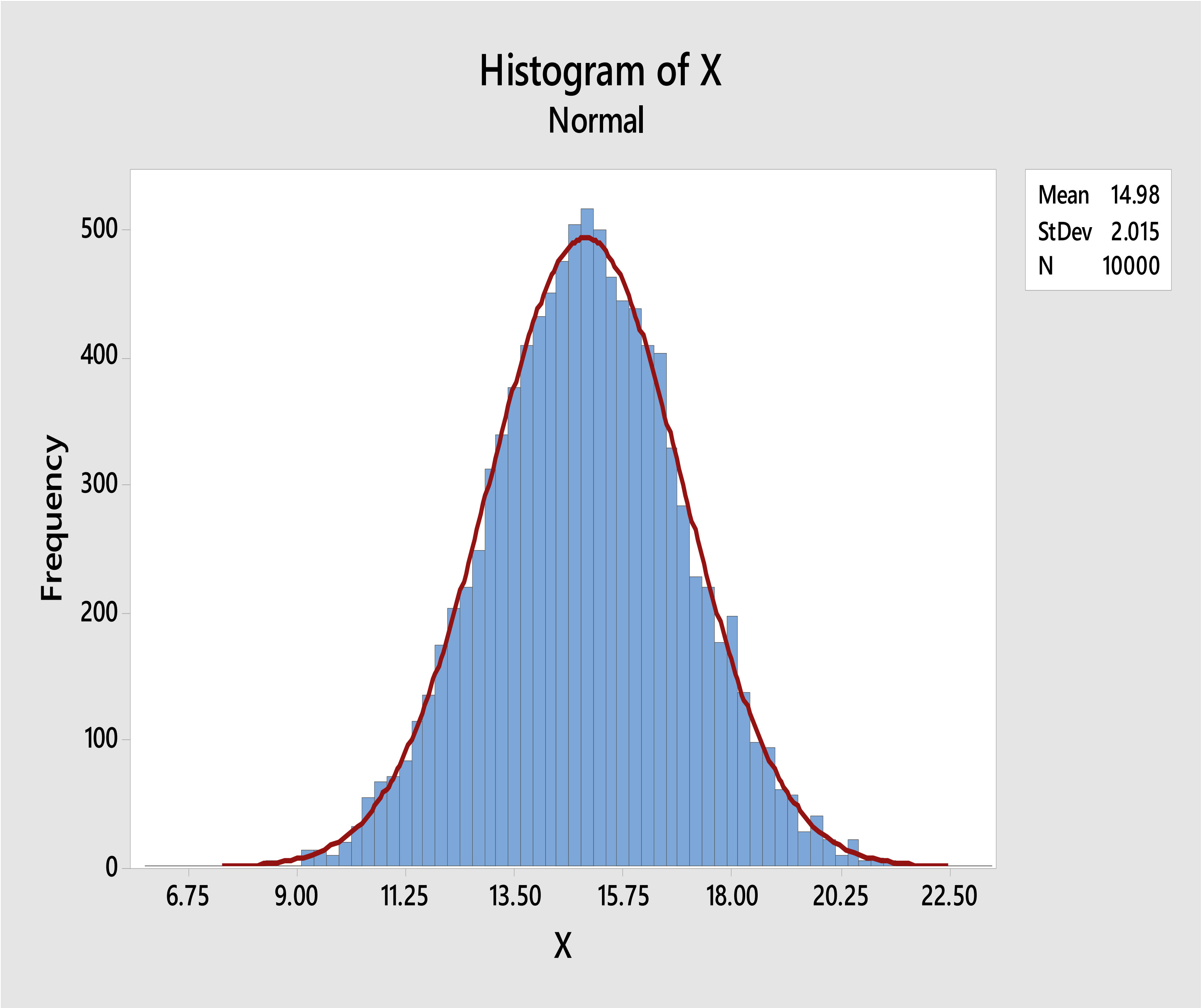
$$ENPV = 2 * 0.35 + 7 * 0.50 + 11 * 0.15 = 5.85$$

Distributions

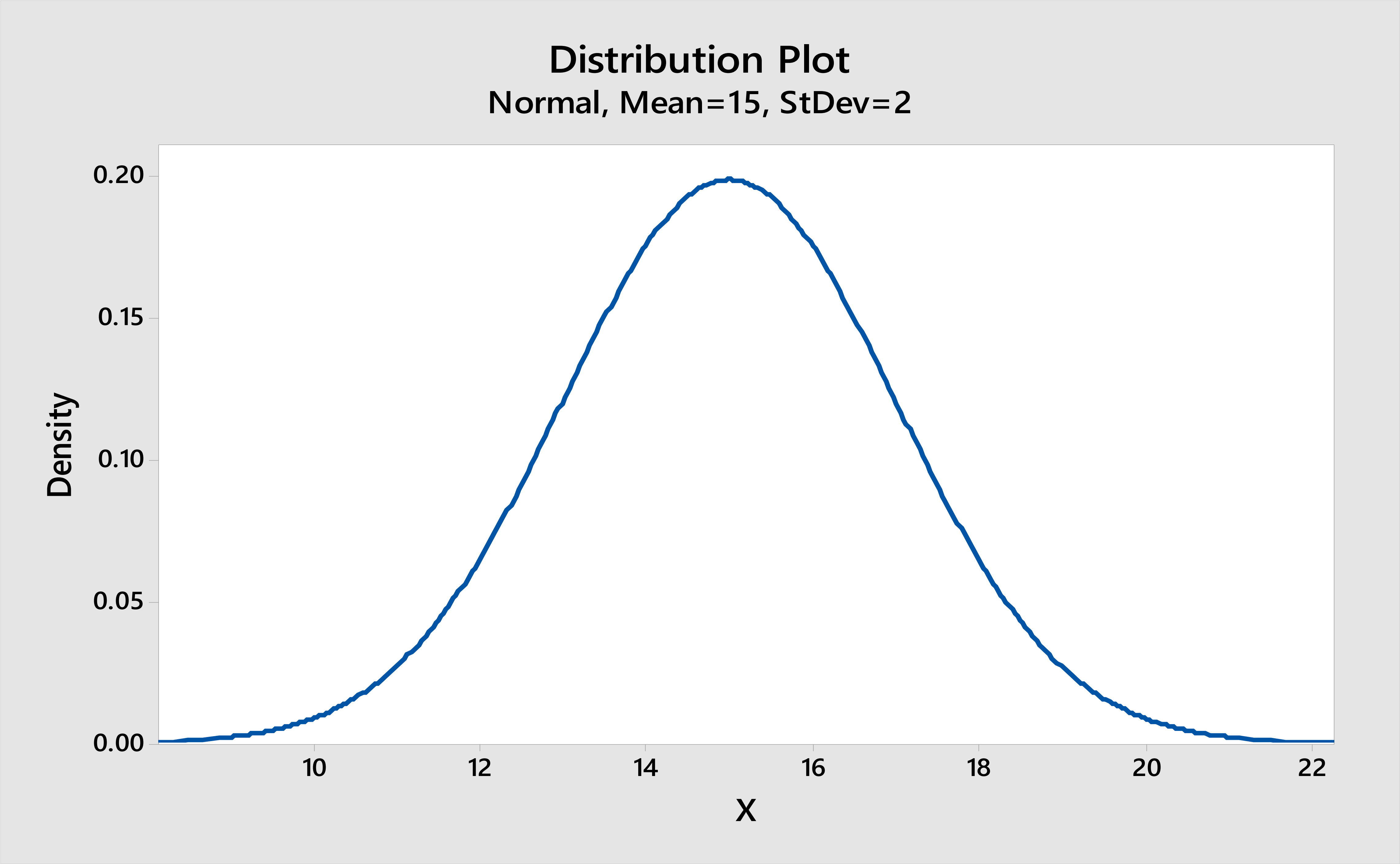


Distributions

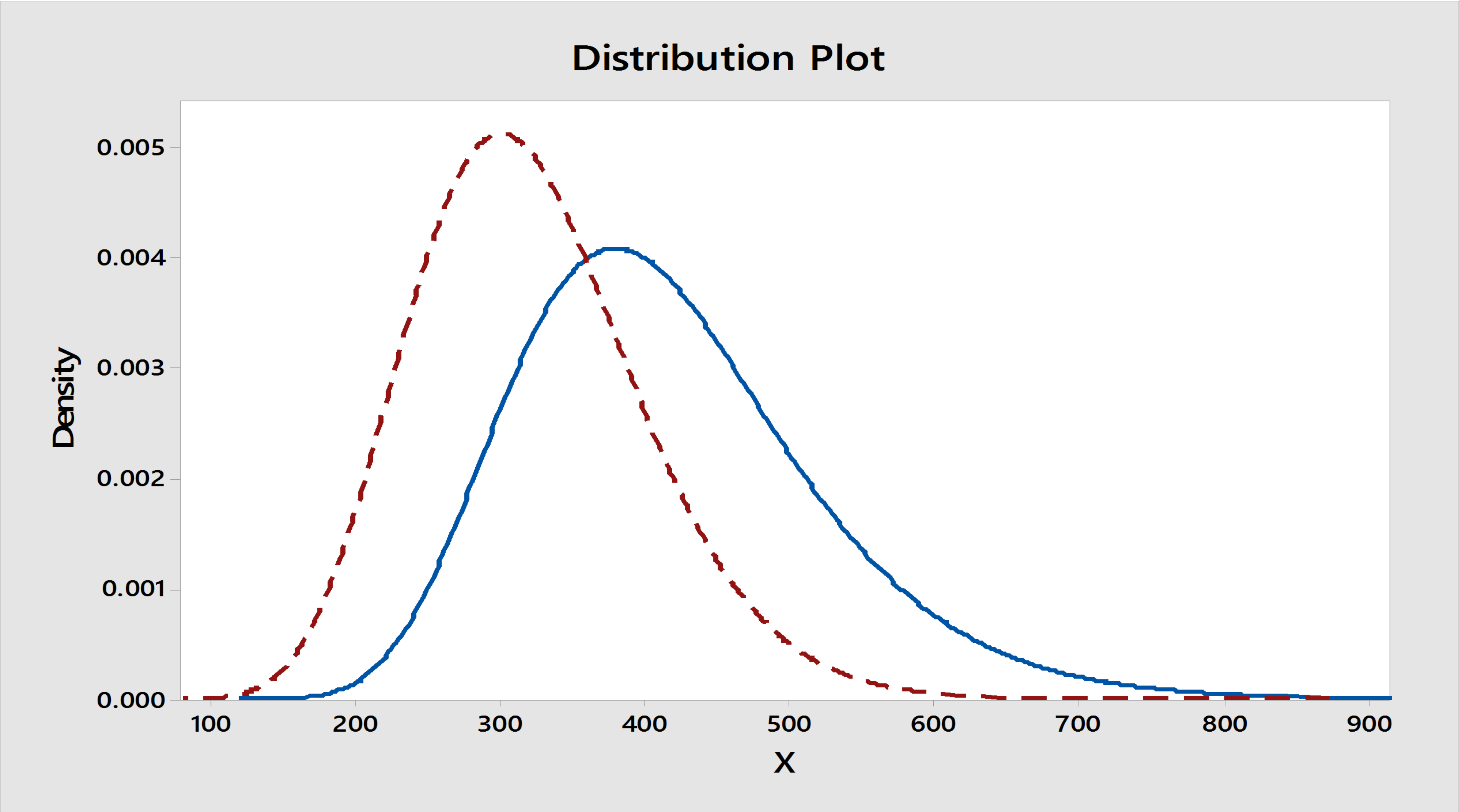


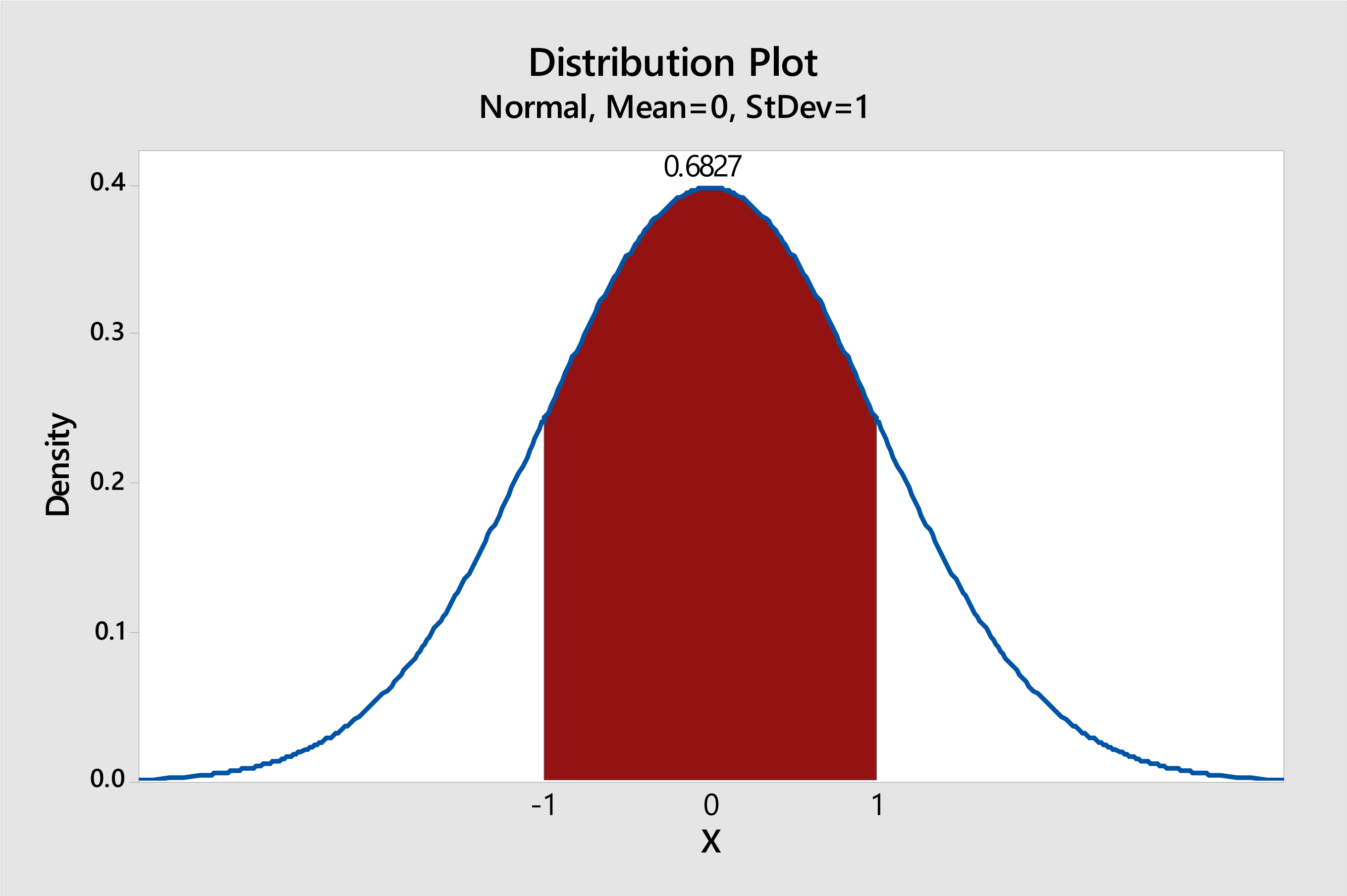


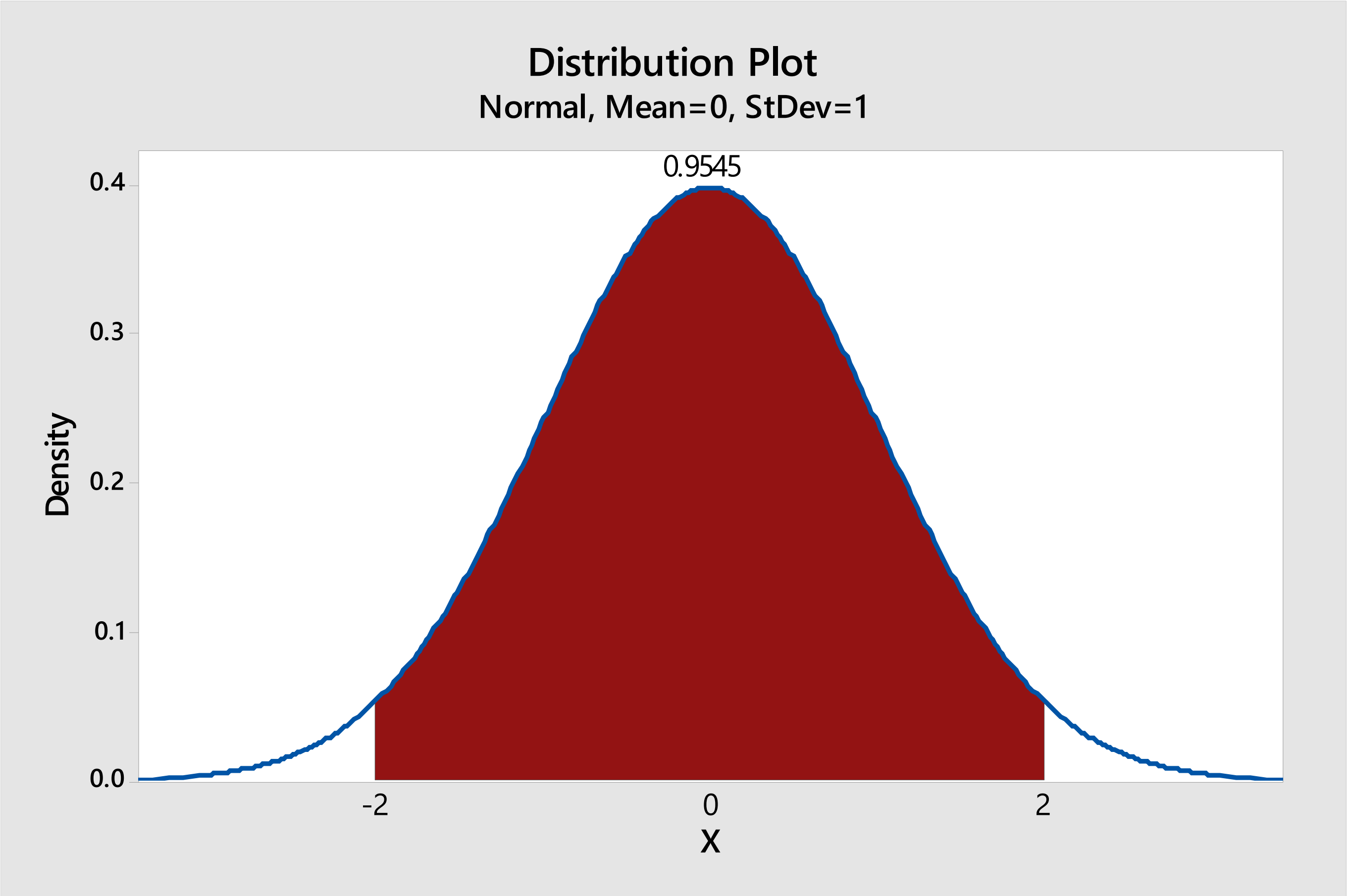
Distributions

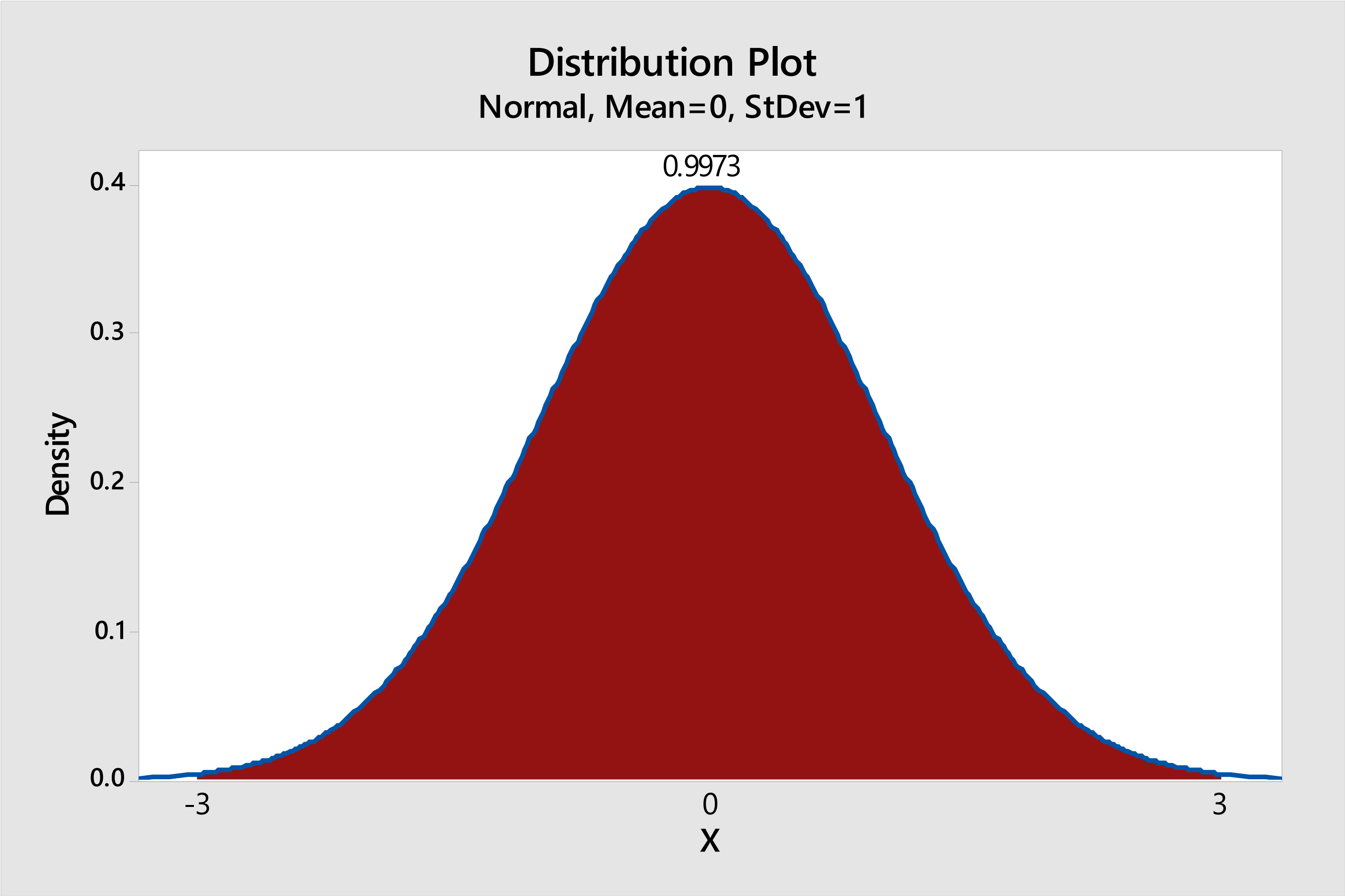


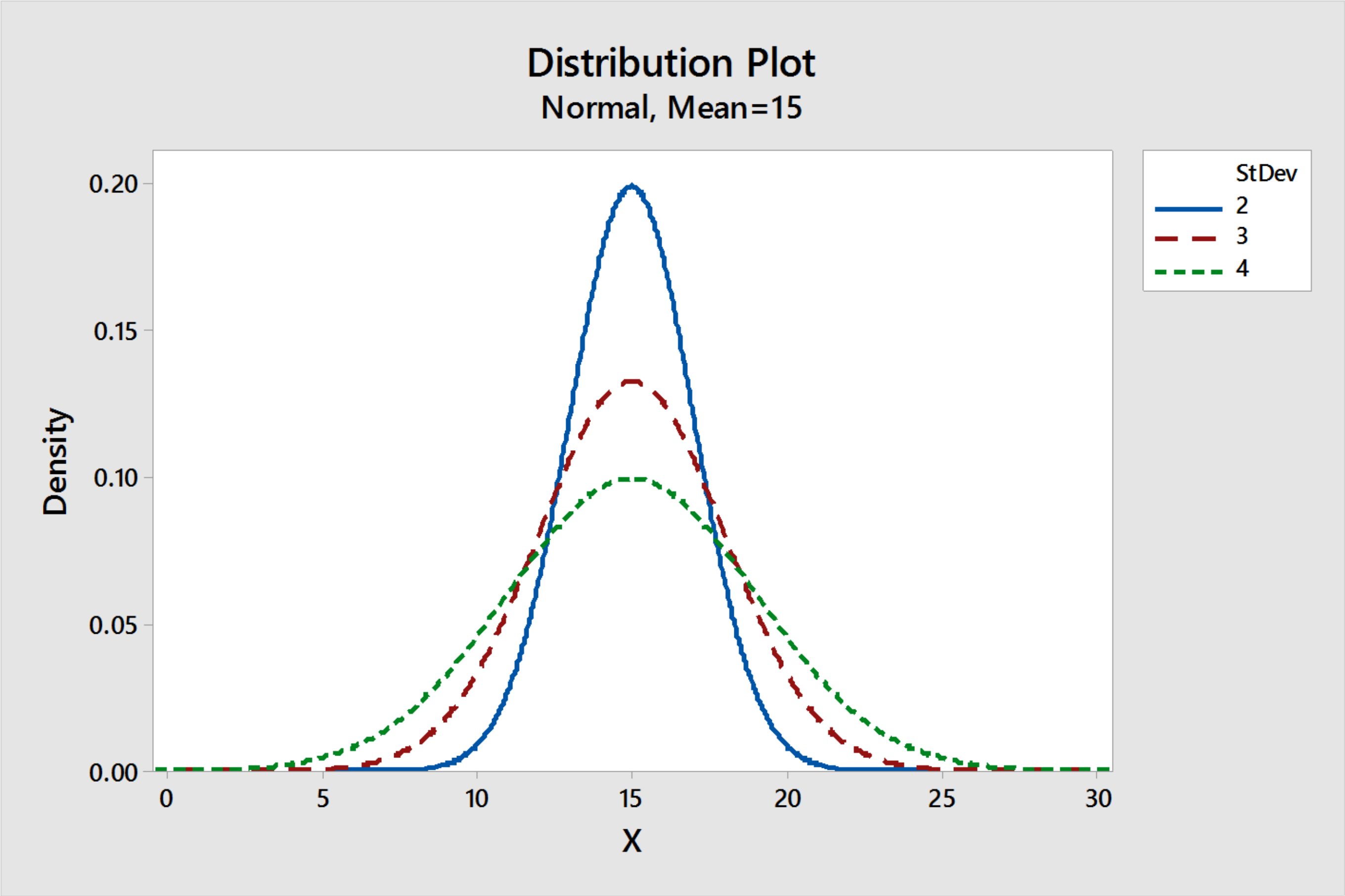
Distributions

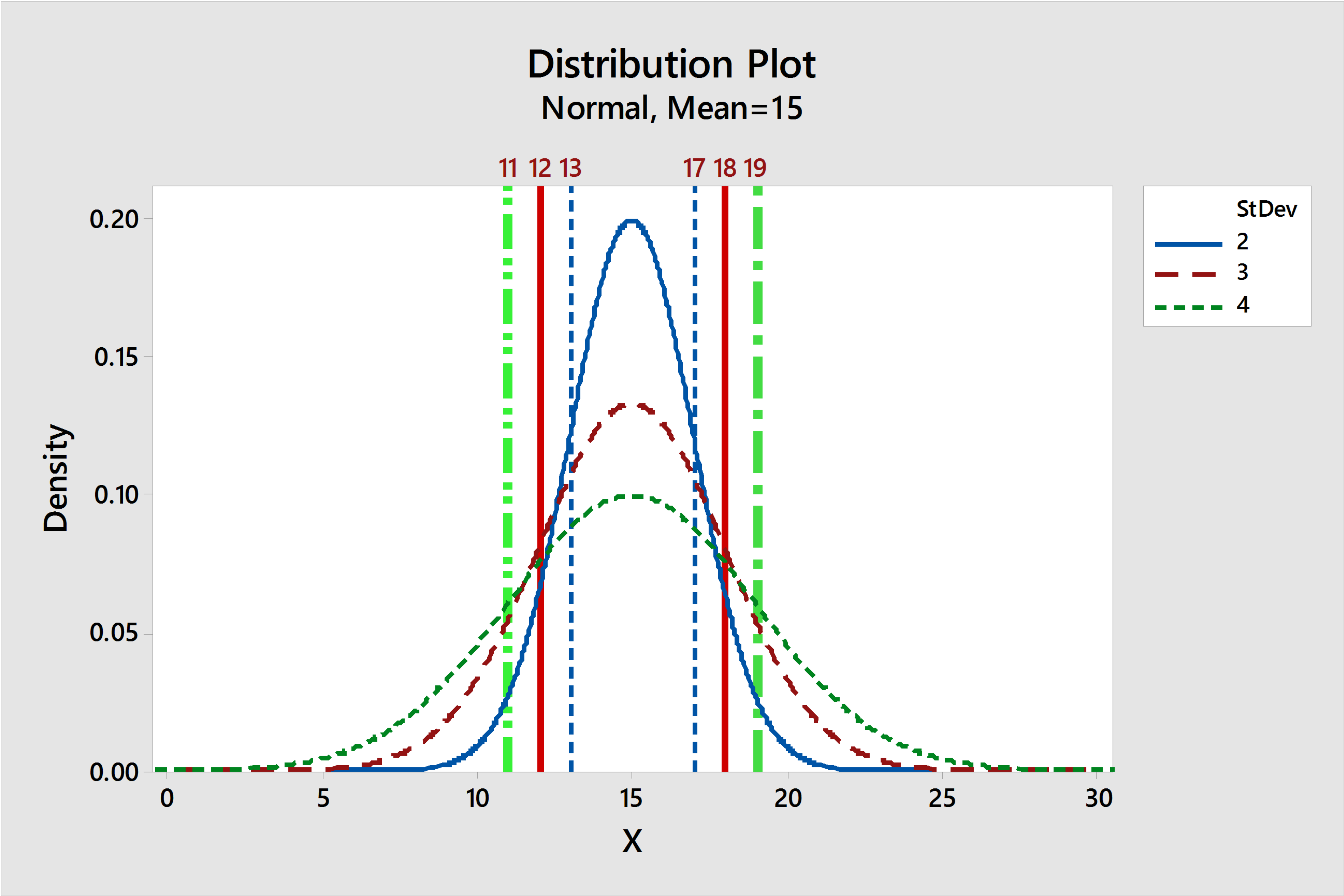



Distribution Plot
Normal, Mean=0, StDev=1
0.6827
Density
0.4
0.3
0.2
0.1
0.0
-1
0
1
X

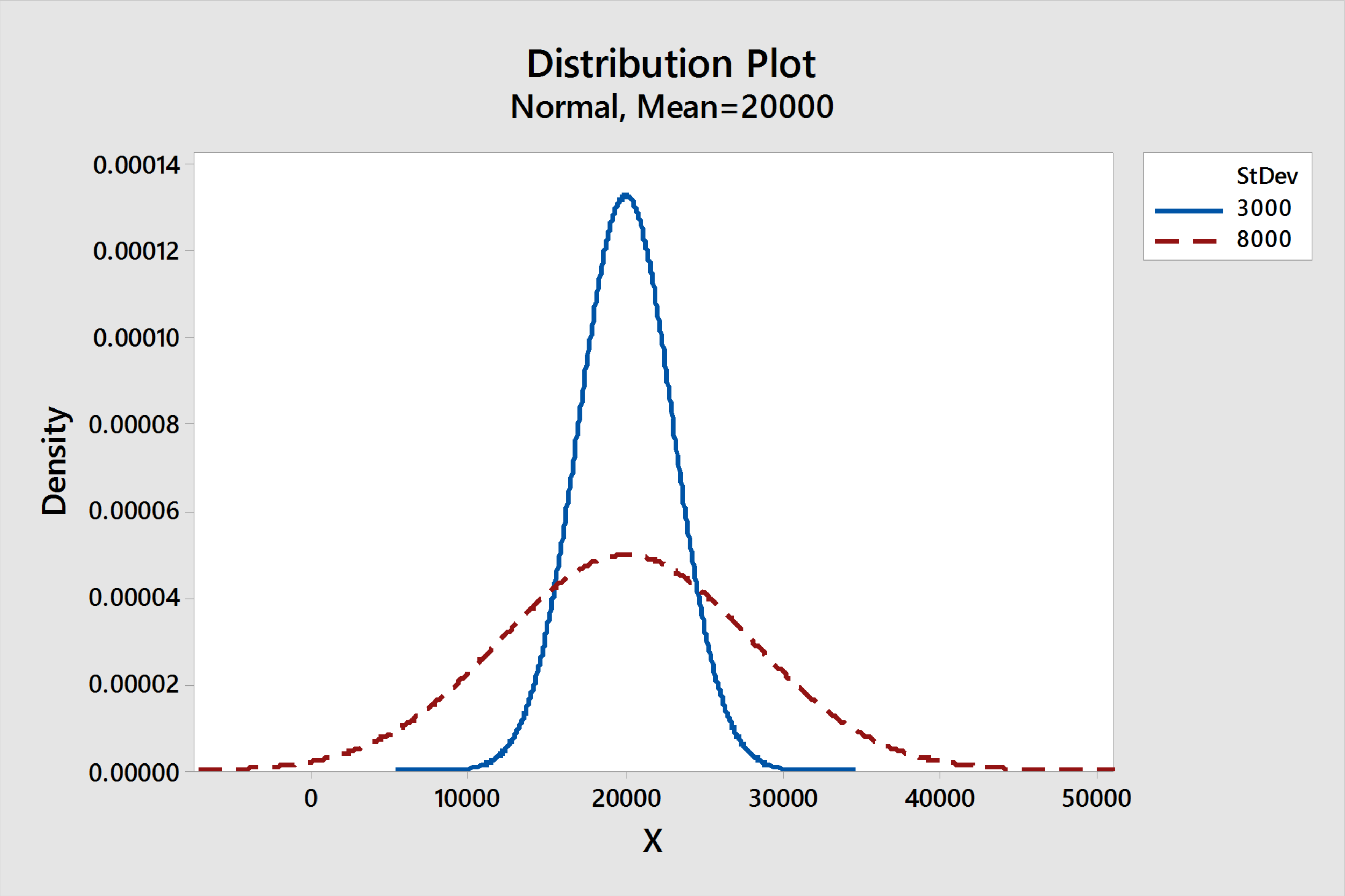

Distribution Plot
Normal, Mean=0, StDev=1
0.9545
Density
0.4
0.3
0.2
0.1
0.0
-2
0
2
X


Distribution Plot
Normal, Mean=0, StDev=1
0.9973
Density
0.4
0.3
0.2
0.1
0.0
-3
0
3
X


Distribution Plot
Normal, Mean=15
StDev
2
3
4
Density
0.20
0.15
0.10
0.05
0.00
0
5
10
15
20
25
30
X


Distribution Plot
Normal, Mean=15
11 12 13
17 18 19
Density
0.20
0.15
0.10
0.05
0.00
0
5
10
15
20
25
30
X
StDev
2
3
4

Distributions

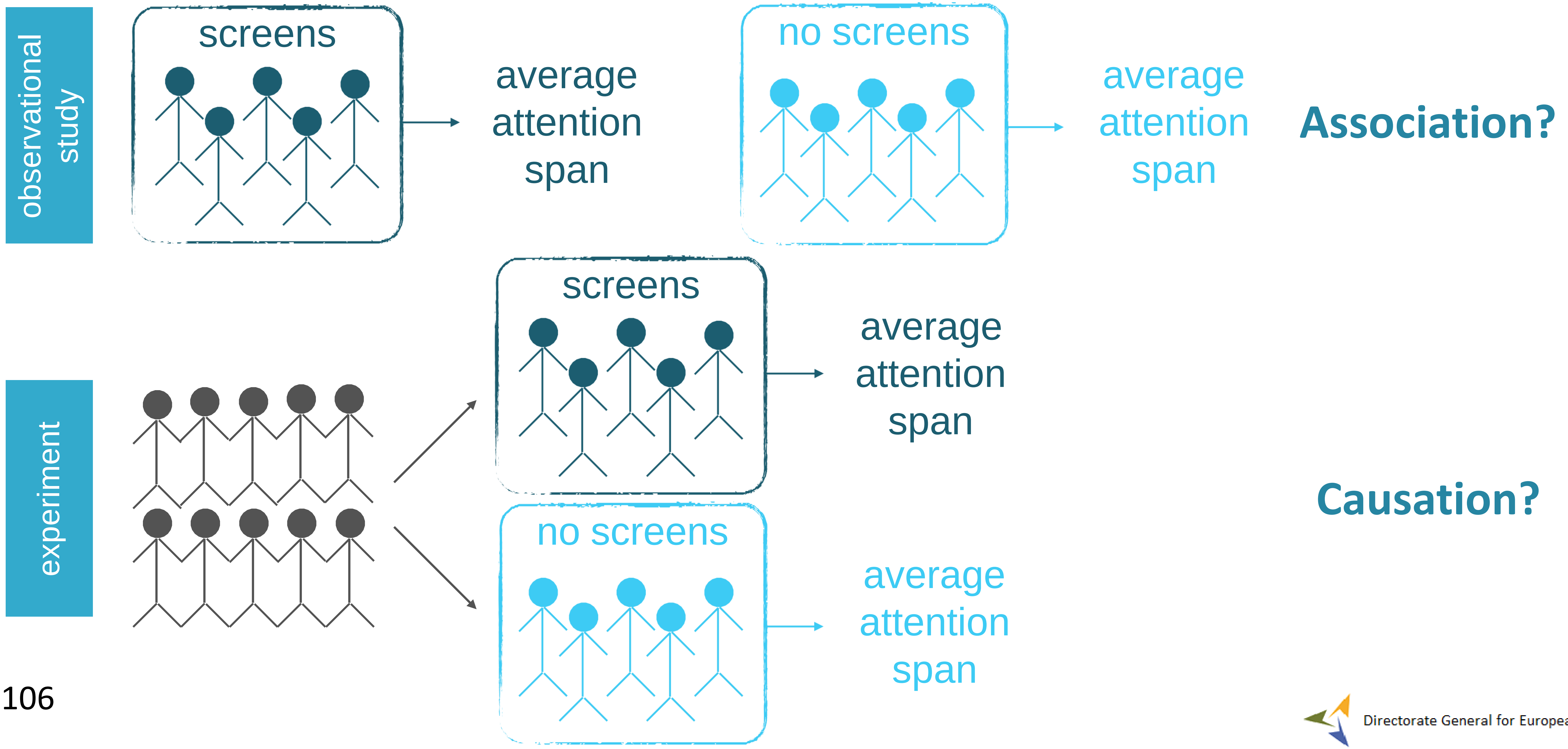


Types of studies

- **Observational study:**
  - Collect data in a way that does not directly interfere with how the data arise
  - Only correlation can be inferred
- **Experiment:**
  - Randomly assign subjects to various treatments
  - Causation can be inferred

Design a study

Screens at bedtime and attention span



Random…

- **Random sampling:**
  - At selection of subjects from population
  - Helps generalizability of results
- **Random assignment:**
  - At selection of subjects from population
  - Helps infer causation from results

Scope of inference

	Random assignment	No random assignment	
Random sampling	Causal and generalizable	Not causal, but generalizable	Generalizable
No random sampling	Causal, but not generalizable	Neither causal nor generalizable	Not generalizable
	Causal	Not causal	

Explanatory and response

x (explanatory)	y (response)

Multivariate relationships

x_1 (explanatory)	x_2 (explanatory)	x_3 (explanatory)	y (response)

Preliminary Skills – Statistics - Sampling

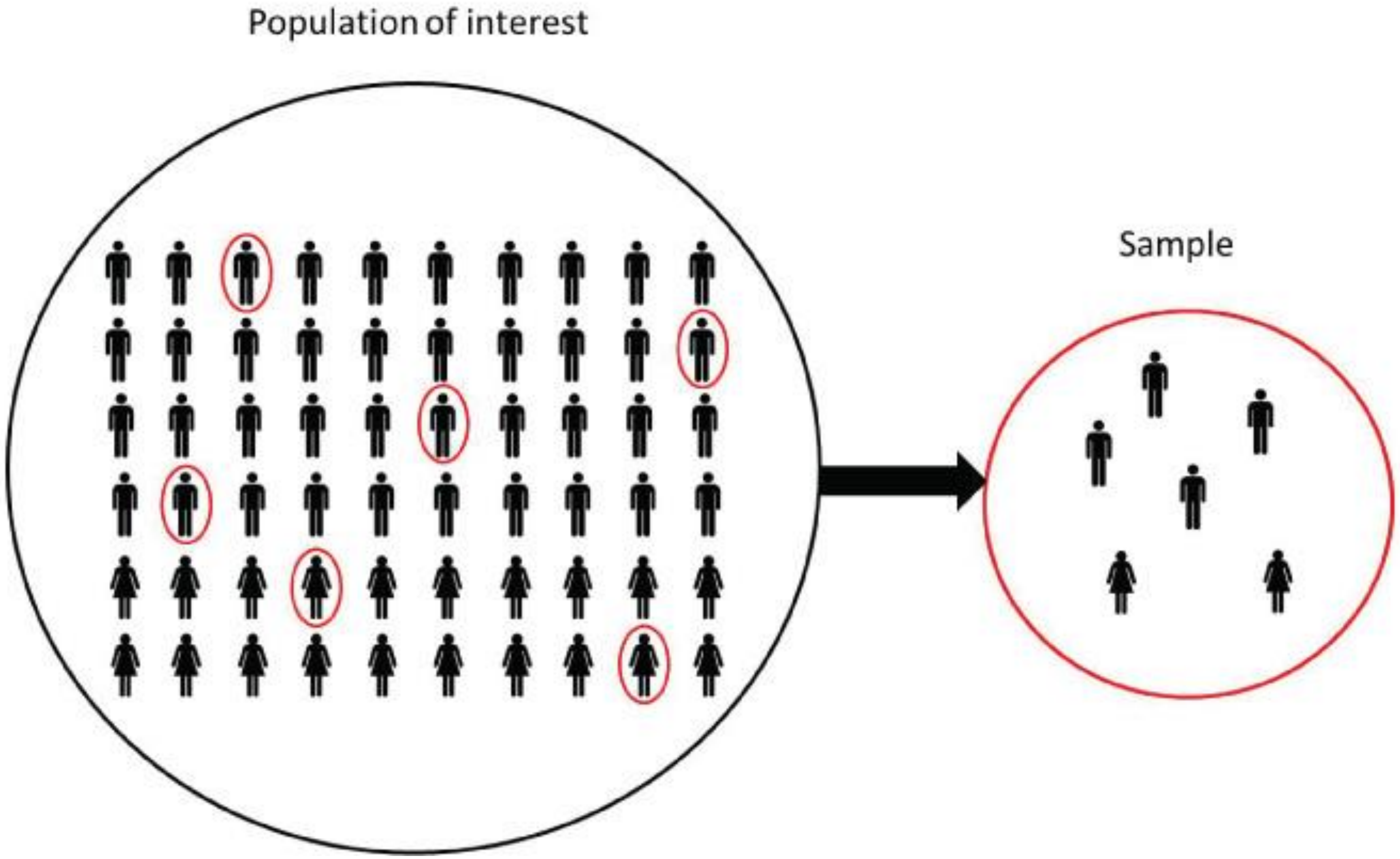
- Population
- Sample

Preliminary Skills – Statistics - Sampling

"You don't have to eat the whole ox to know that the meat is tough…"

Samuel Johnson

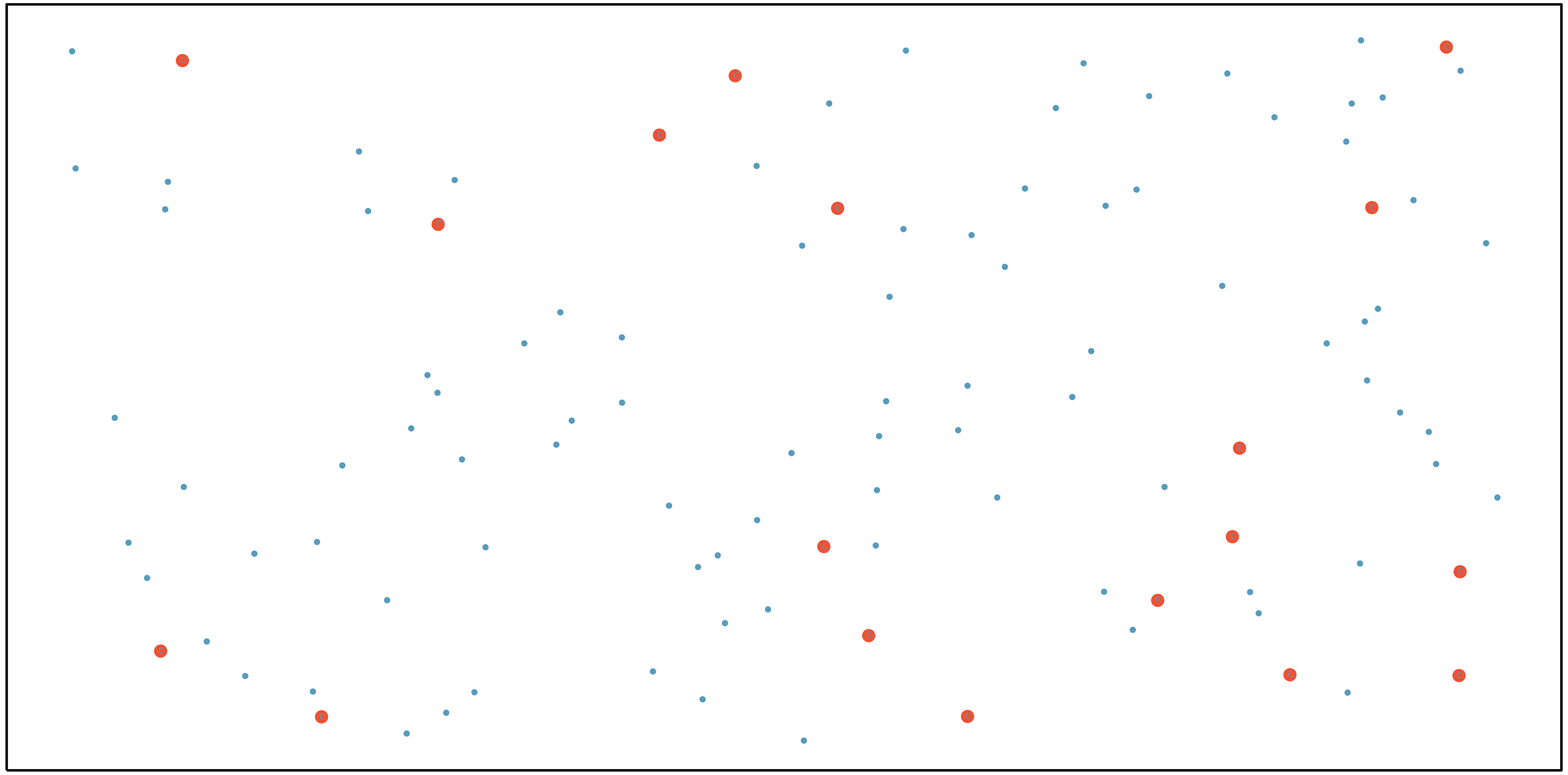
Preliminary Skills – Statistics – Sampling



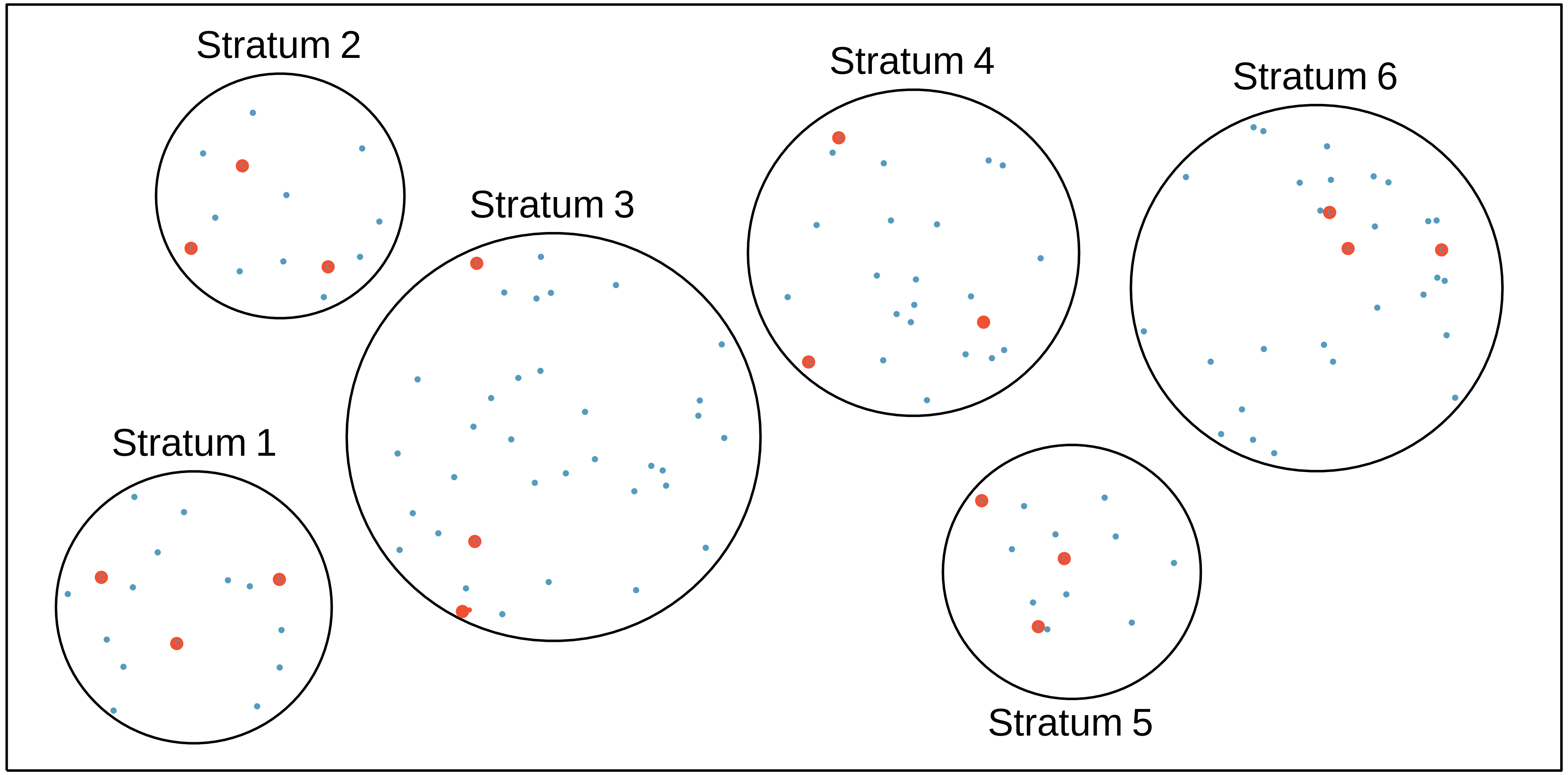
Preliminary Skills – Statistics - Sampling

- Probability Random Sampling
- Non Probability Random Sampling

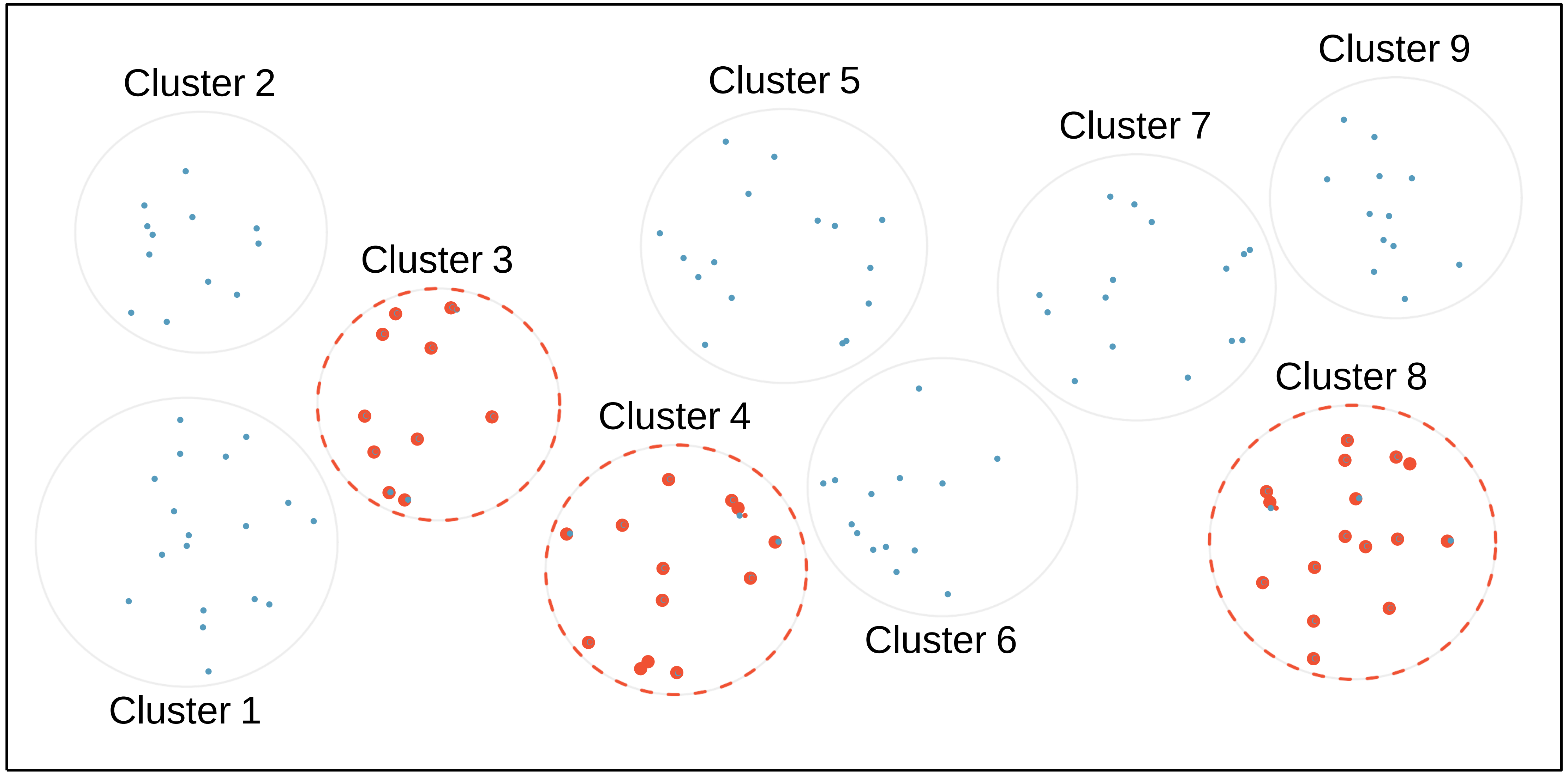
Simple random sample



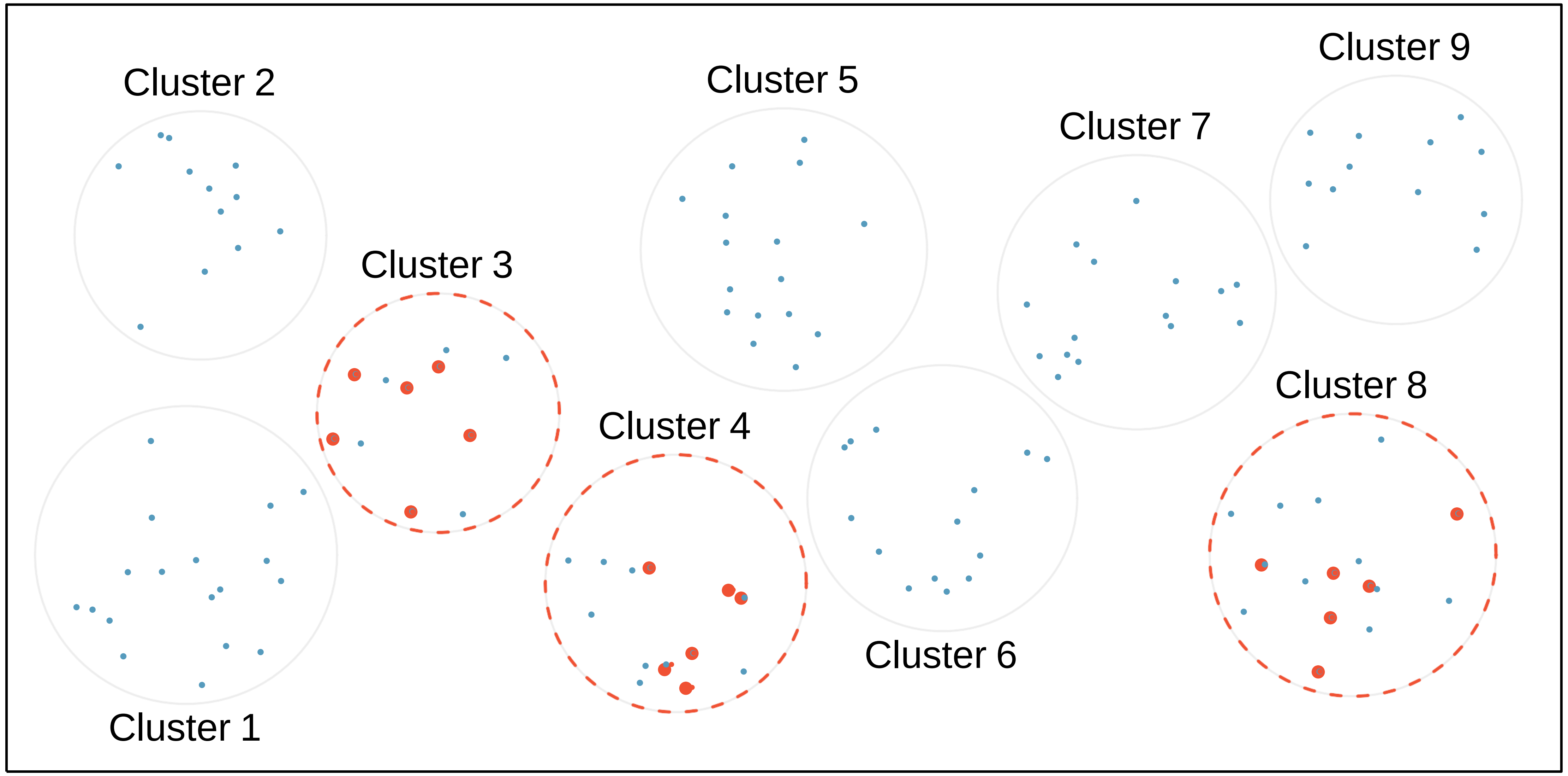
Stratified random sample



Cluster sample



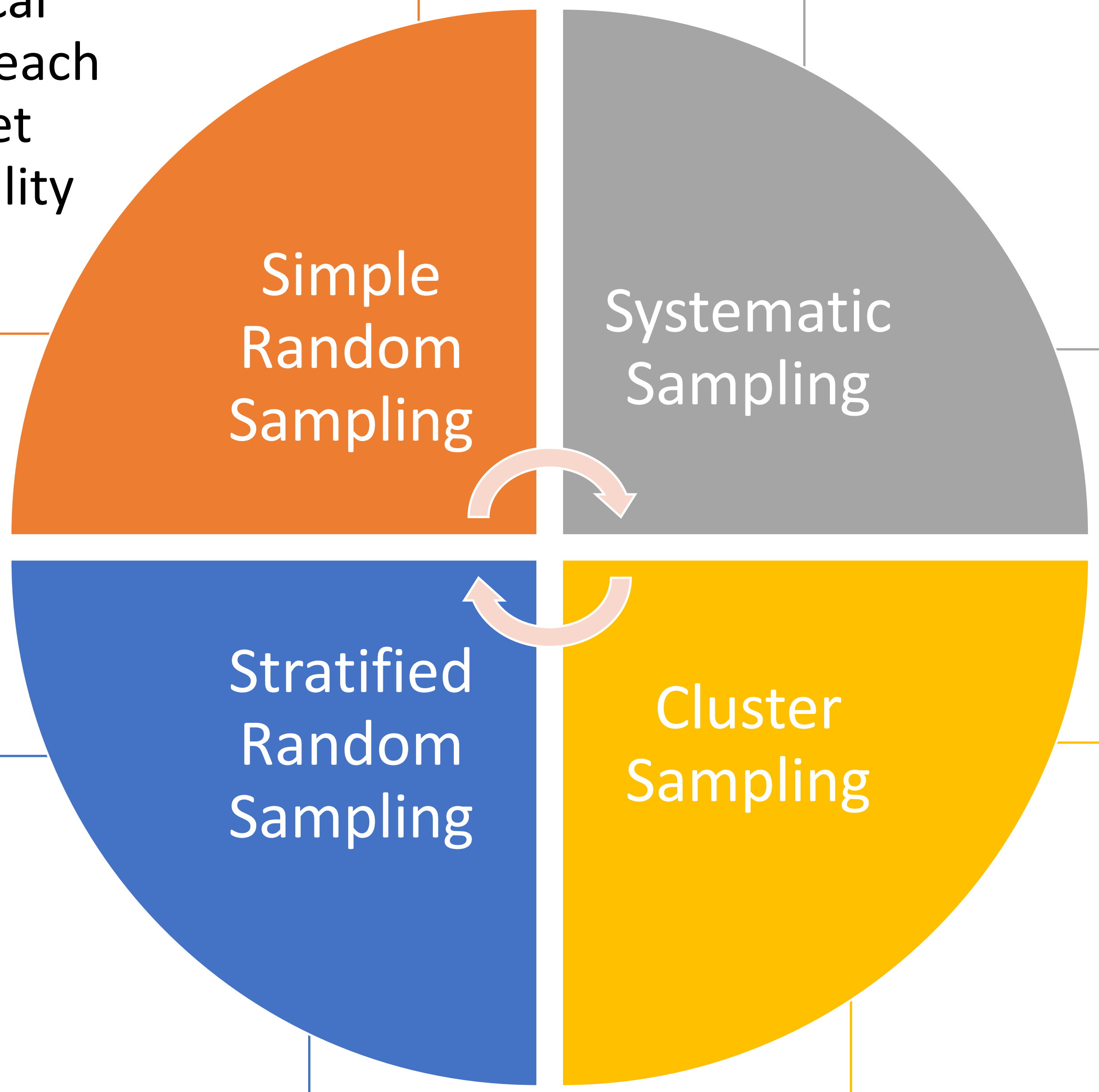
Multistage cluster sample



Probability Sampling

- A subset of a statistical population in which each member of the subset has an equal probability of being chosen

- Selection of elements from an ordered population. The sampling starts by selecting an element from the list at random and then every k^{th} element in the frame is selected, where k, the sampling interval



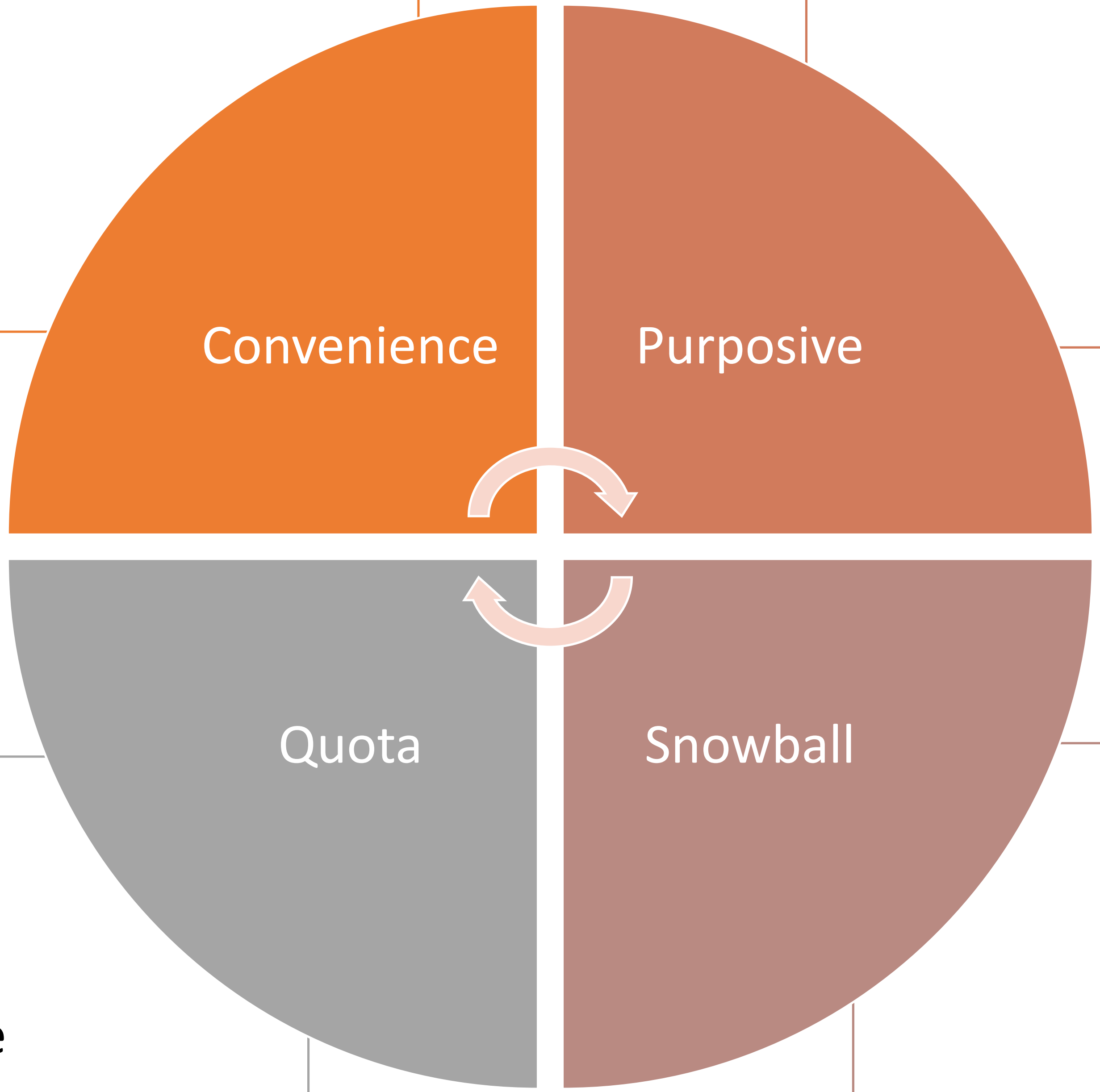
- Population is divided into subgroups (strata) and subjects selected randomly

- Population is divided to clusters and simple random sampling is selected from clusters

Non-Probability Sampling

- Based on ease of accessibility

- Deliberate select sample to conform to some criteria



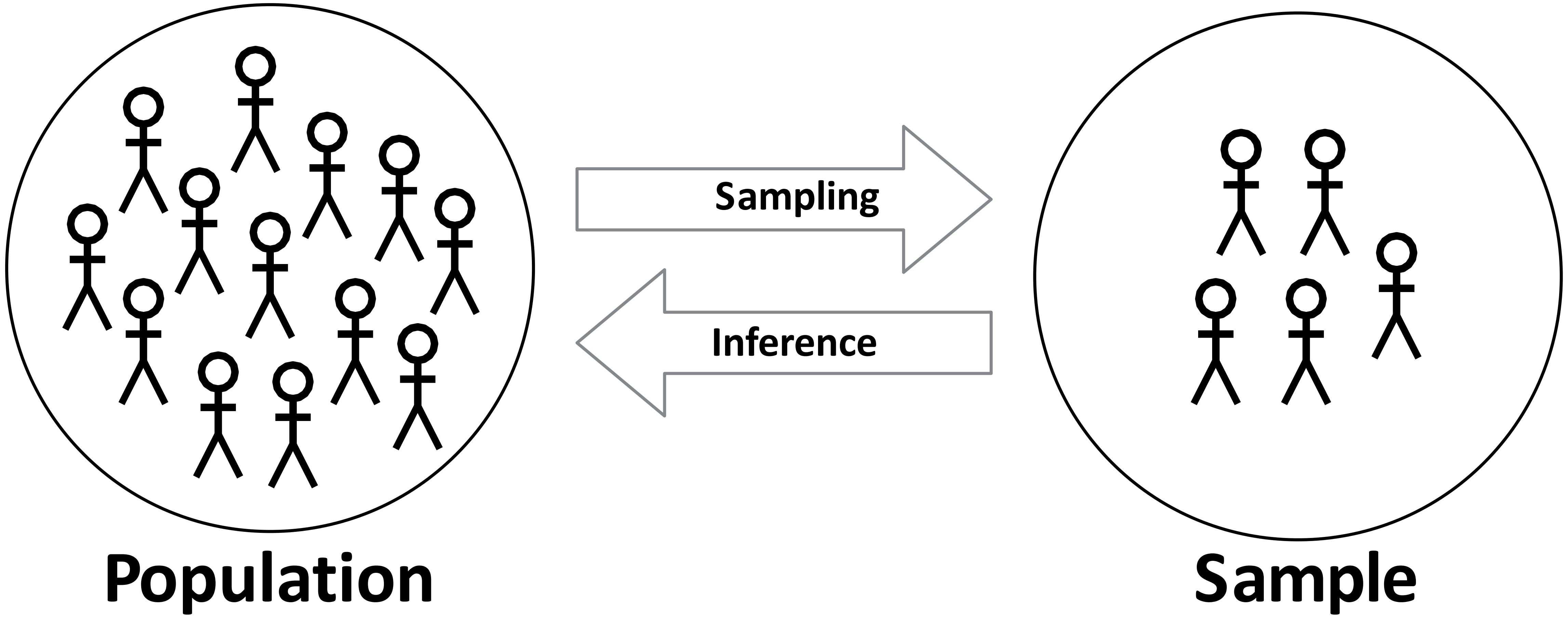
- Relevant characteristics are used to segregate the sample

- Referred by current sample elements

What is statistical inference?

The process of making claims about a population based on information from a sample

What is statistical inference?



Vocabulary

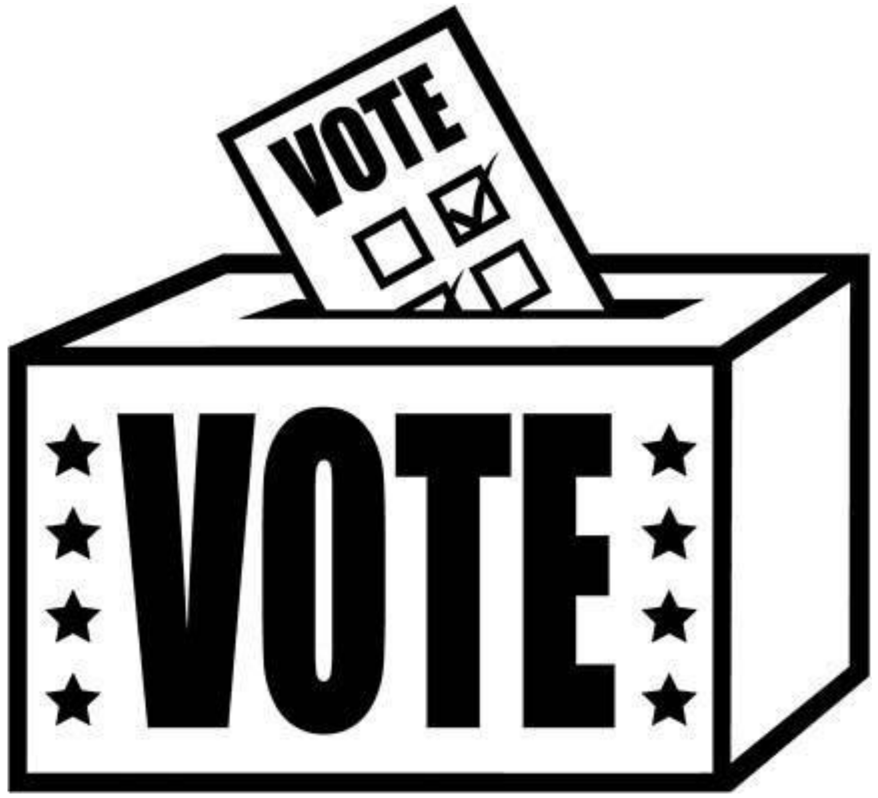
- Null hypothesis (H_0): The claim that is not interesting
- Alternative hypothesis (H_A): The claim corresponding to the research hypothesis

Understanding the null distribution

Generating a distribution of the statistic from the null population gives information about whether the observed data are inconsistent with the null hypothesis

Example: election

- From a sample, the researchers would like to claim that Candidate X will win A population measure!
- H_0: Candidate X will get half the votes
- H_A: Candidate X will get more than half the votes



- H_0: $p = .50$
- H_A: $p > .50$

Hypothesis Testing

- The test procedure can be summarized as follows:
- Decide on a null hypothesis H_0 and an alternative hypothesis H_A
- Select a test statistic (i.e. sample mean or the sample variance, proportion etc.)
- Choose level of significance (α) (in practice $\alpha = 0.05$)
- Make a Decision
  - $p < \alpha$ (0.05) reject the null hypothesis
  - $p \neq \alpha$ (0.05) fail to reject the null hypothesis

Parameters and confidence intervals

Parameters

- A parameter is ***a numerical value*** from the population
- Examples:
  - The true average amount all dieters will lose on a particular program
  - The proportion of individuals in a population who recommend Subaru cars
  - The average income of all individuals in the population with a particular education level

Confidence Interval

- ***Range of numbers*** that (hopefully) captures the true parameter
- "95% confident that between 12% and 34% of the entire population recommends ……."

Interpreting CIs

- Goal is to find the parameter when all we know is the statistic
- Never know whether the sample you collected actually contains the true parameter
- Interpreting the CIs
  - Percentile interval: (0.533, 0.833)
  - We are 95% confident that the true proportion of people planning to vote for candidate X is between 0.536 and 0.864
- When our goal is ***to estimate*** we use Confidence Intervals

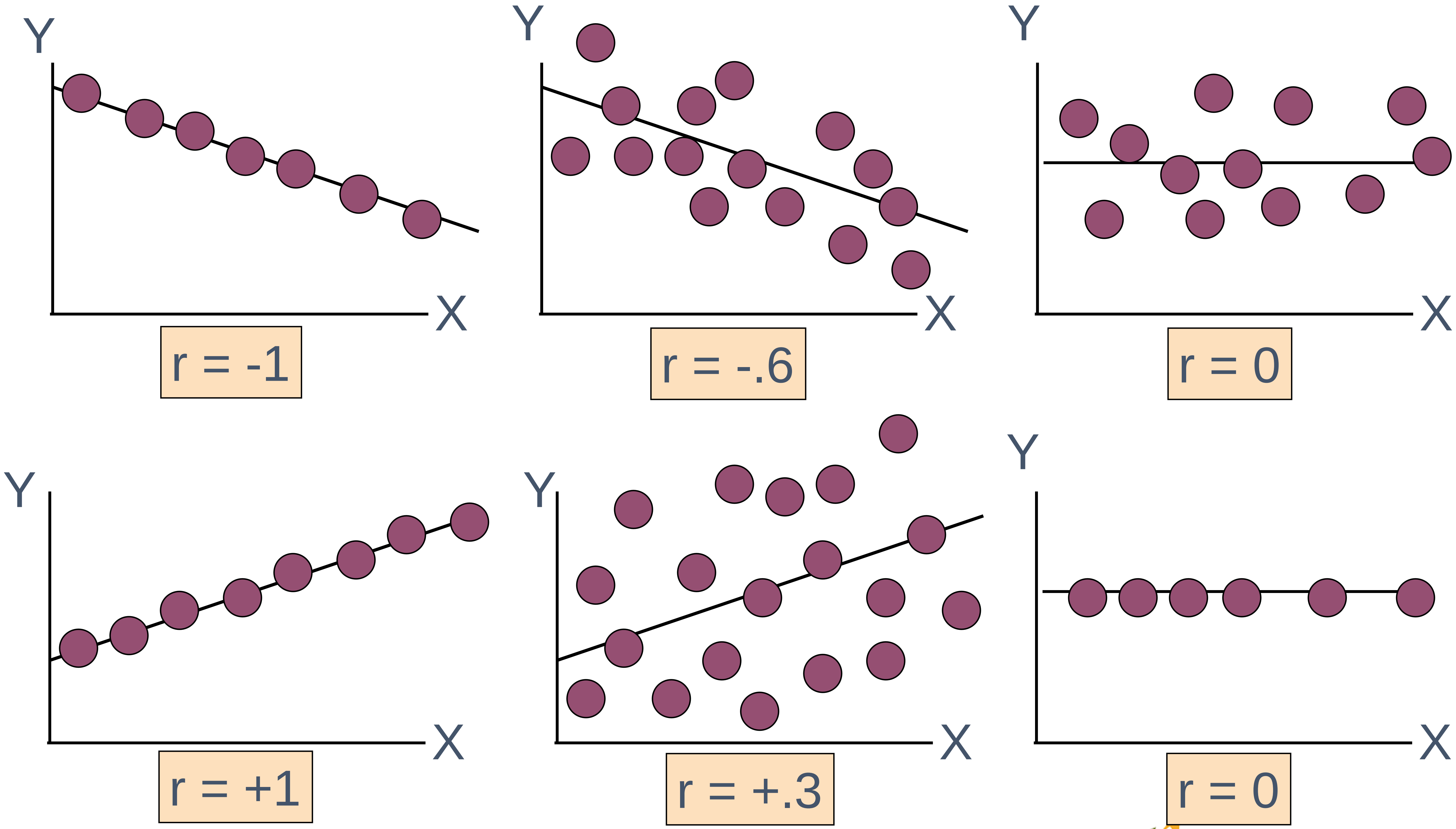
Research questions

Hypothesis testing	Confidence interval
Under which diet plan will participants lose more weight on average?	How much should participants expect to lose on average?
Which of two car manufacturers are users more likely to recommend to their friends?	What percent of users are likely to recommend Subaru to their friends?
Are education level and average income linearly related?	For each additional year of education, what is the predicted average income?

Correlation

- Correlation coefficient between -1 and 1
- Sign —> direction
- Magnitude —> strength

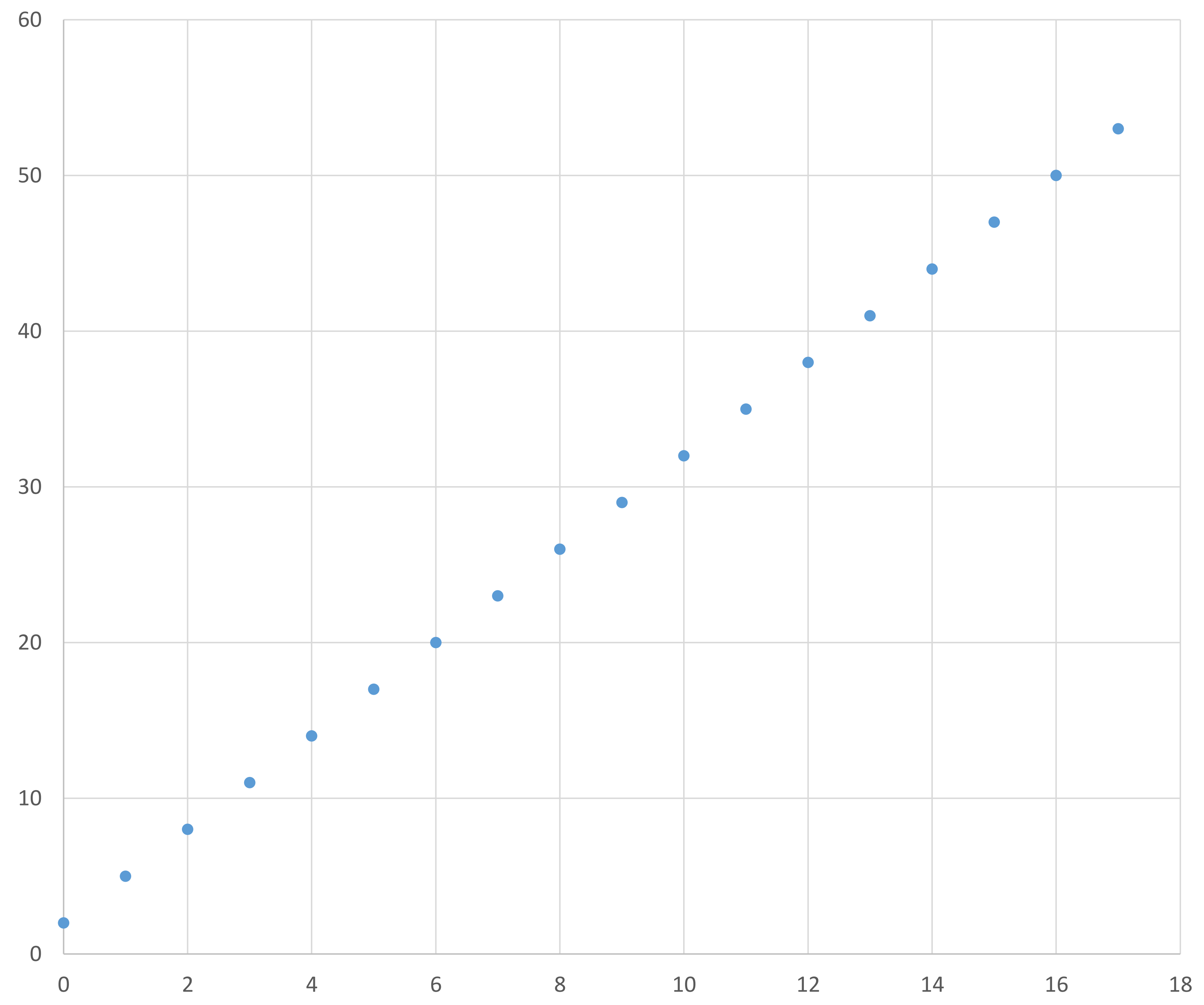
Scatter Plots of Data with Various Correlation Coefficients



Regression

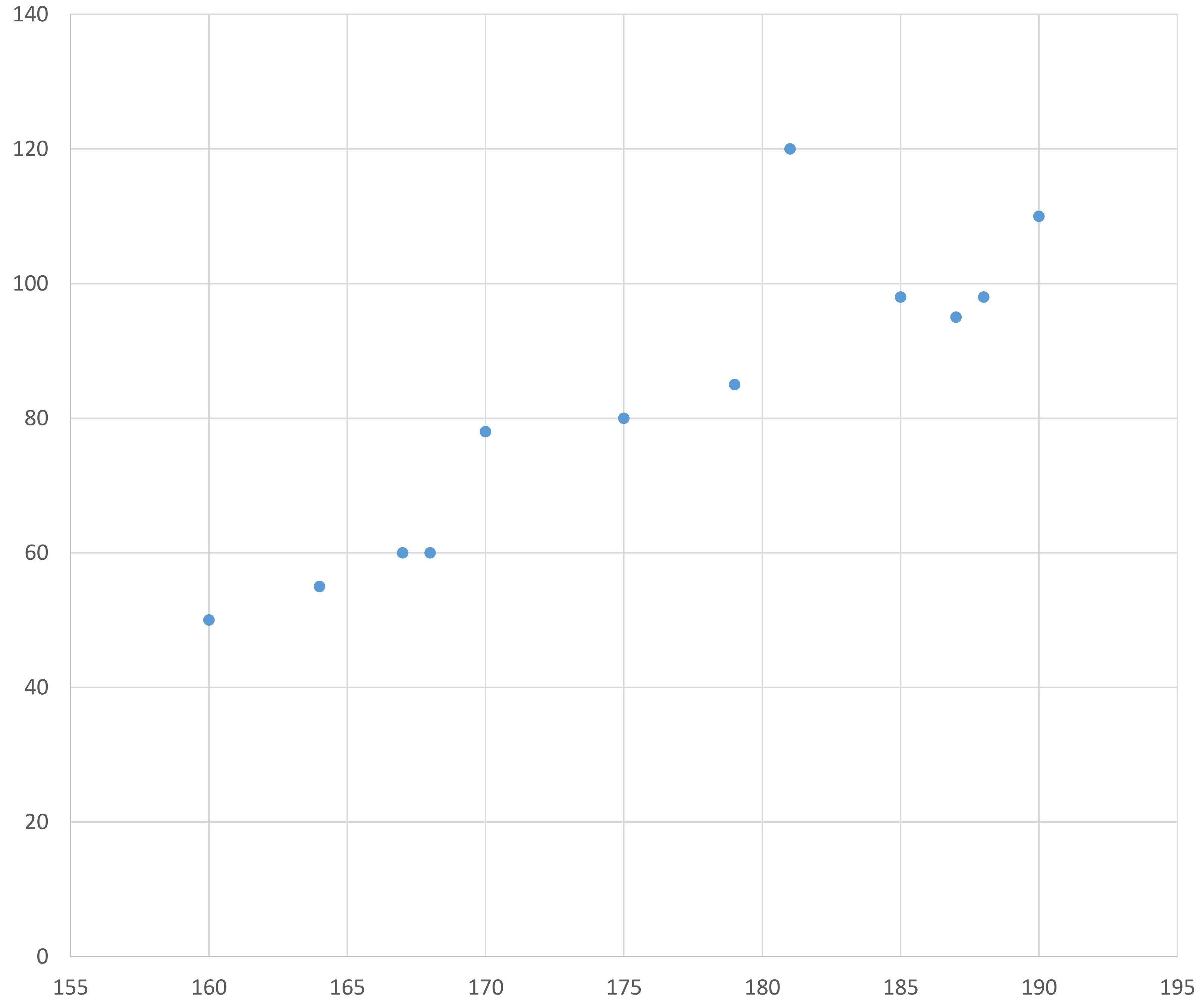
- $y = mx + c$
- Consider $y = 3x + 2$

x	y
0	2
1	5
2	8
3	11
…..	



Regression

Height	Weight
170	78
167	60
175	80
168	60
185	98
190	110
188	98
187	95
….	



Regression

Height	Weight
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167	60
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168	60
185	98
190	110
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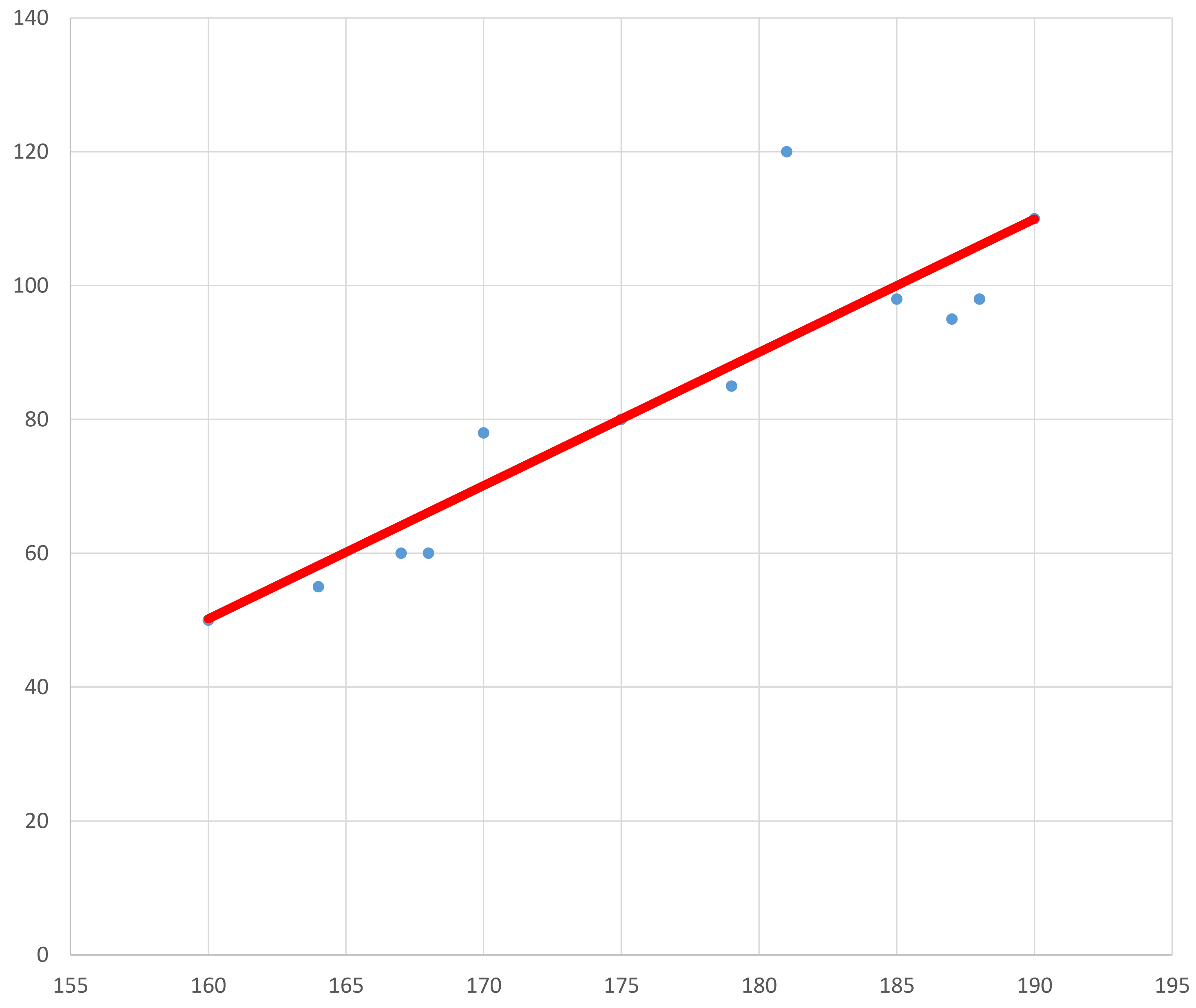
187	95
….	



Regression

- Simple Regression
- $Y = \beta_o + \beta_1 X_1$
- Multiple Regression
- $Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \ldots \beta_n X_n$

Regression

Data

Height (x)	Weight (y)
170	78
167	60
175	80
168	60
185	98
190	110
188	98
187	95
179	85
181	120
160	50
164	55

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.901
R Square	0.811
Adjusted R Square	0.793
Standard Error	10.329
Observations	12

ANOVA

	df	SS	MS	F	Significance F
Regression	1	4590.089	4590.089	43.026	0.000
Residual	10	1066.827	106.683		
Total	11	5656.917			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-268.37	53.56	-5.01	0.001	-387.71	-149.03
Height (x)	1.99	0.30	6.56	0.000	1.31	2.67

Regression

Step 1: Determine whether the association between the response and the term is statistically significant

- The null hypothesis is that there is no association between the term and the response.
  - H_O: $\beta_1 = 0$
  - H_A: $\beta_1 \neq 0$
  - To determine whether the association between the response and each term in the model is statistically significant, compare the p-value for the term to your significance level to assess the null hypothesis. ($\alpha = 0.05$)

Regression

Step 2: Determine how well the model fits your data

- Standard Error
  - Use Standard Error to assess how well the model describes the response. Standard Error is measured in the units of the response variable and represents how far the data values fall from the fitted values. The lower the value of S, the better the model describes the response. However, a low S value by itself does not indicate that the model meets the model assumptions.
- R square
  - How much of the variation (noise) the model explains.

Regression

Step 3: Determine whether your model meets the assumptions of the analysis

- Use the residual plots to help you determine whether the model is adequate and meets the assumptions of the analysis. If the assumptions are not met, the model may not fit the data well and you should use caution when you interpret the results.

ANOVA Table Degrees Of Freedom

Cook Distances

Covariance Matrix

Correlation Matrix

AIC

Adjusted R Squared

ANOVA Table Mean Squares

Standardized Residuals

Covariance Ratios

ANOVA Table

ANOVA Table Entries

Beta Differences

Design Matrix

ANOVA Table F Statistics

BIC

Catcher Matrix

ANOVA Table Sums Of Squares

Assumptions

Best Fit

Response

Predicted Response

Studentized Residuals

Basis Functions

ANOVA Table P Values

Coefficient Of Variation

Parameter Table Entries

Parameter P Values

Best Fit Parameters

Regression Analysis

Parameter Errors

Variance Inflation Factors

F Variance Ratios

Parameter T Statistics

Partial Sum Of Squares

Function

Hat Diagonal

DurbinWatson D

Fit Differences

Mean Prediction Errors

Diagnostic Plots

Estimated Variance

Fit Residuals

Mean Prediction Confidence Intervals

Parameter Confidence Interval Table

Parameter Confidence Intervals

Mean Prediction Confidence Interval Table

Parameter Confidence Interval Table Entries

Mean Prediction Confidence Interval Table Entries

R Squared

Properties

Sequential Sum Of Squares

Parameter Confidence Region

Let’s Practice!!!

Steps in Project Appraisal

9 Identify the preferred project alternative - Recommendation

8 Assess affordability and sustainability

7 Analyse risks and plan for their management

6 Calculate NPV for all project alternatives

5 Value economic benefits and costs

4 Identify relevant benefits and costs

3 Demonstrate the demand for the services

2 Identify and choose project alternatives

1 Define the project objectives and scope

Step 1
Define the Project Objectives and Scope

1 Overall Objective

- General objectives such as income increases, standard of living improvement, poverty reduction, natural resources protection etc. to which the purpose is going to contribute.

2 Project Purpose

- The project's central objective expressed in terms of the achievement of sustainable benefits for the target group

3 Project Outputs

- Achievements created by the project, which produce the services or facilities corresponding to the project purpose.

Specific

Measurable

Achievable

Relevant

Time-bound

Let’s Practice!!!

Example - Water and Waste Water Infrastructure

The main objective of the project is to ensure increased environmental integrity and compliance with the Urban Waste Water Treatment Directive and with the National Programme of Water Supply and Wastewater Treatment through incremental collection and compliant treatment of wastewater load, and extension of water supply coverage. Collection rates are expected to increase to 99 % by extending the sewage network to a further 15,000 people and ensuring that the connection rate (i.e. transfer to a compliant WWTP rather than untreated discharge directly to the recipient water body) is 100 %. An estimated 7,500 people will also be connected to the public water supply network, thereby increasing overall water supply coverage to 99.5 %.Sludge will be dried and composted to allow final disposal to agricultural land. Finally, the chemical status of the river running through the city will be improved from 'moderate' to 'good' in accordance with the definitions of the Water Framework Directive. The project objectives are well aligned with the main goals of the priority axis 1 - 'Water and Sewerage Management' of the operational programme 'Environment & Infrastructure'. In particular, the investment will contribute to the achievement of the following operational programme targets at national level:

Indicator	OP 2023 target	Project (% of target)
Additional population newly connected to public water supply system network	120,000	7,500 (6.25 %)
Additional population newly connected to the sanitary sewage system network	300,000	15,000 (5 %)
Increase in the number of agglomerations meeting the requirements of Directive 91/271/EEC (numbers) including: agglomerations over 100,000 p.e (population equivalent)	10	1 (10 %)

Taken from Guide to Cost-Benefit Analysis of Investment Projects *Economic appraisal tool for Cohesion Policy 2014-2020 p. 179*

Steps in Project Appraisal

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2 Identify and choose project alternatives

1 Define the project objectives and scope

Step 2
Identify and Choose Project Alternatives

- Using different technological approaches or different technologies;
- Varying the timing, phasing and scale of a capital investment;
- Renting, building or purchasing facilities;
- Refurbishing existing public facilities instead of building new;

Step 2
Identify and Choose Project Alternatives

- Changing the balance between capital and recurrent expenditure, such as by choosing between more or less capital intensive service provision;
- Sharing facilities with other agencies;
- Changing locations or sites; and
- Improved implementation of existing measures or initiatives instead of investing.

Why?

Comparison of life-cycle costs and benefits of the reference project and feasible project alternatives

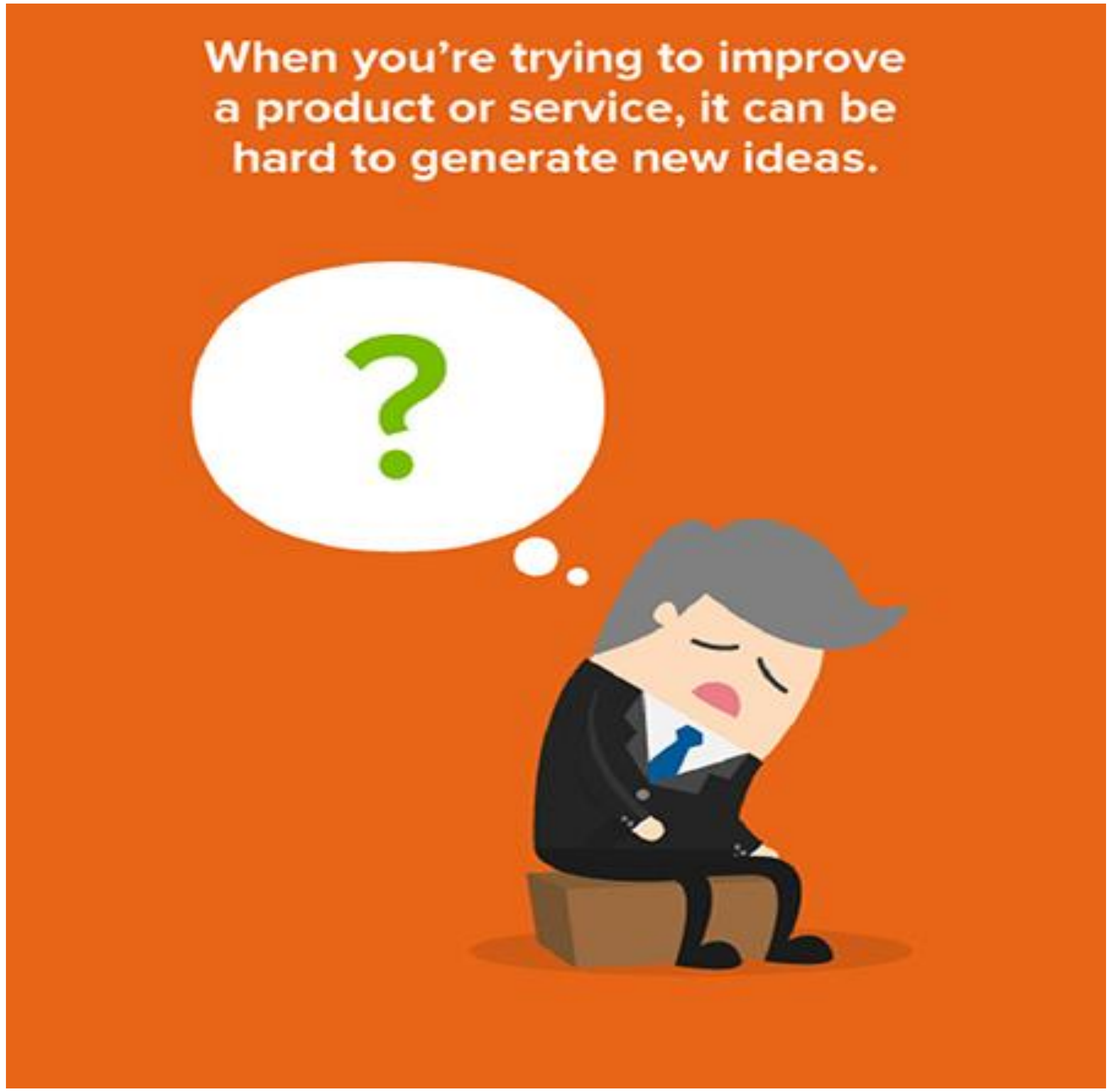
“Business-as usual” / “do nothing” / “status quo” / “Zero Intervention”

Always an alternative

Step 2
Identify and Choose Project Alternatives

Sector	Years
Railways	30
Roads	25-30
Ports and airport	25
Urban transport	25-30
Water supply & sanitation	30
Waste management	25-30
Energy	15-25
Broadband	15-20
Business infrastructure	10-15
Buildings	20
Other sectors	10-15

Step 2
Identify and Choose Project Alternatives



SCAMPER

Step 2
Identify and Choose Project Alternatives

- Substitute
- Combine
- Adapt
- Modify
- Put to another use
- Eliminate
- Reverse

Example

The objective is to satisfy the water demand for domestic, agricultural, industrial, environmental and other uses, to the maximum extent possible

- Scenario 1 : "Zero Intervention";
- Scenario 2 : "Construction of a new permanent desalination plant";
- Scenario 3 : "Expansion of Episkopi desalination plant and Interconnection with Asprogremmos Water Treatment Plant reservoirs";
- Scenario 4 : "Installation of a mobile desalination plant when needed".

Steps in Project Appraisal

9 Identify the preferred project alternative - Recommendation

8 Assess affordability and sustainability

7 Analyse risks and plan for their management

6 Calculate NPV for all project alternatives

5 Value economic benefits and costs

4 Identify relevant benefits and costs

3 Demonstrate the demand for the services

2 Identify and choose project alternatives

1 Define the project objectives and scope

Demonstrate the Demand for the Services of the Project and Alternatives

Designing appropriately sized capital assets with the necessary capacity for current and future users

Demonstrate the Demand for the Services of the Project and Alternatives

Making reliable cost estimates

Estimating the benefits of the project accurately

Demonstrate the Demand for the Services of the Project and Alternatives

Arriving at a robust conclusion on the economic viability of the project

Extrapolation

"Simply extrapolating current trends without question is not, acceptable. This has been a frequent cause of over- or under-investment in many countries."

Manual for Pre-Selection and Appraisal of Public Investment Projects

Government of Cyprus

Optimism Bias

Over-optimistic forecasts of demand are a worldwide cause of poor public investment decisions

EUROPEAN INVESTMENT BANK

UNIVERSIDAD POLITECNICA DE MADRID

Research Paper

Why traffic forecasts in PPP contracts are often overestimated?

EIB University Research Sponsorship Programme

Final Draft

Updated: December 3, 2007

Study Finds Traffic Forecasts Consistently Overestimating Congestion

Researchers from Denmark and Norway have looked at the accuracy of traffic forecasts for road projects. Their conclusion is that the forecasts systematically overestimate traffic growth rates and the resulting congestion effects.

December 8, 2014, 10am PST | Nicolai

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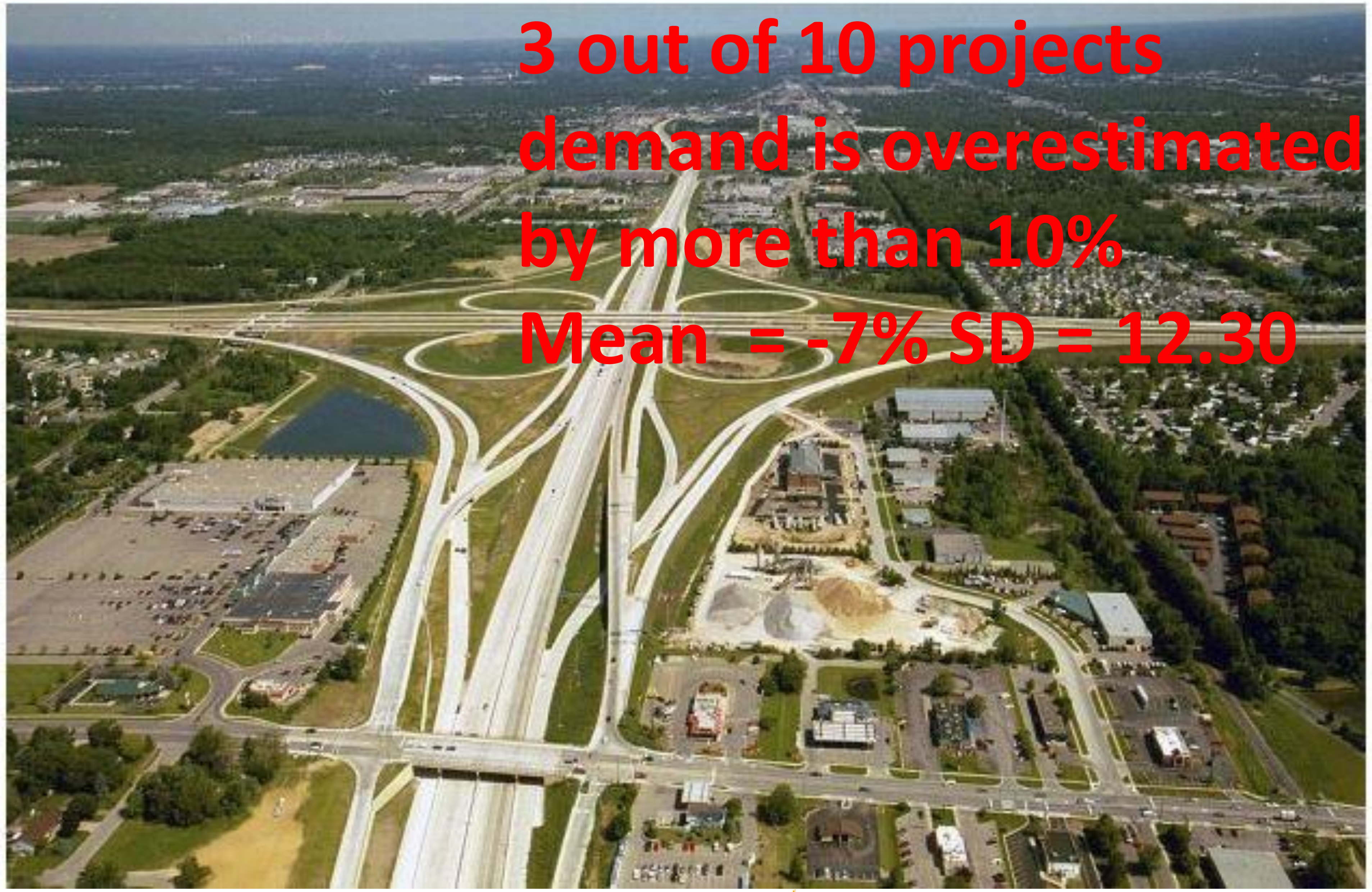


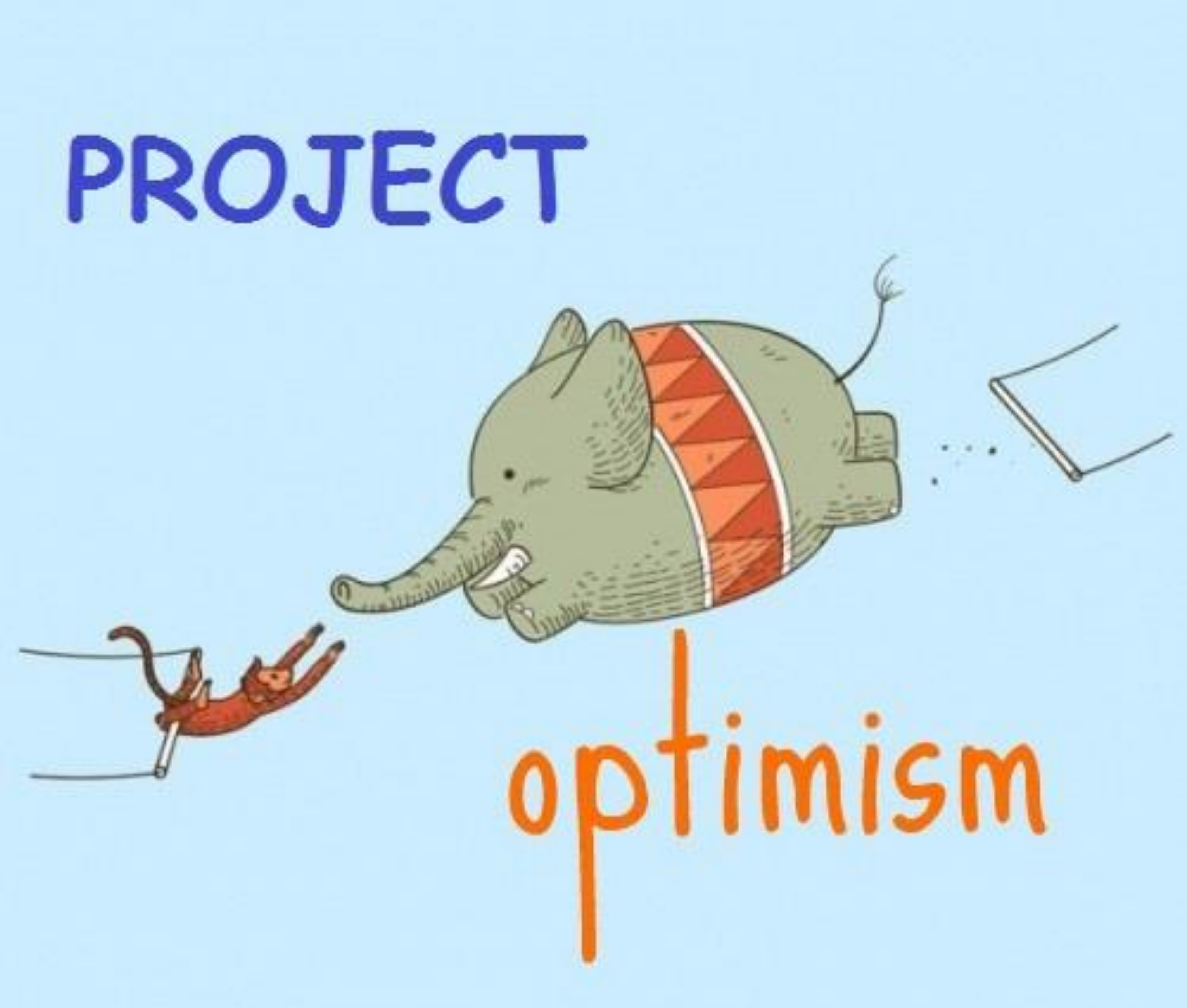
Santiago's transport system is sputtering

Commuters do not want to pay for bad service

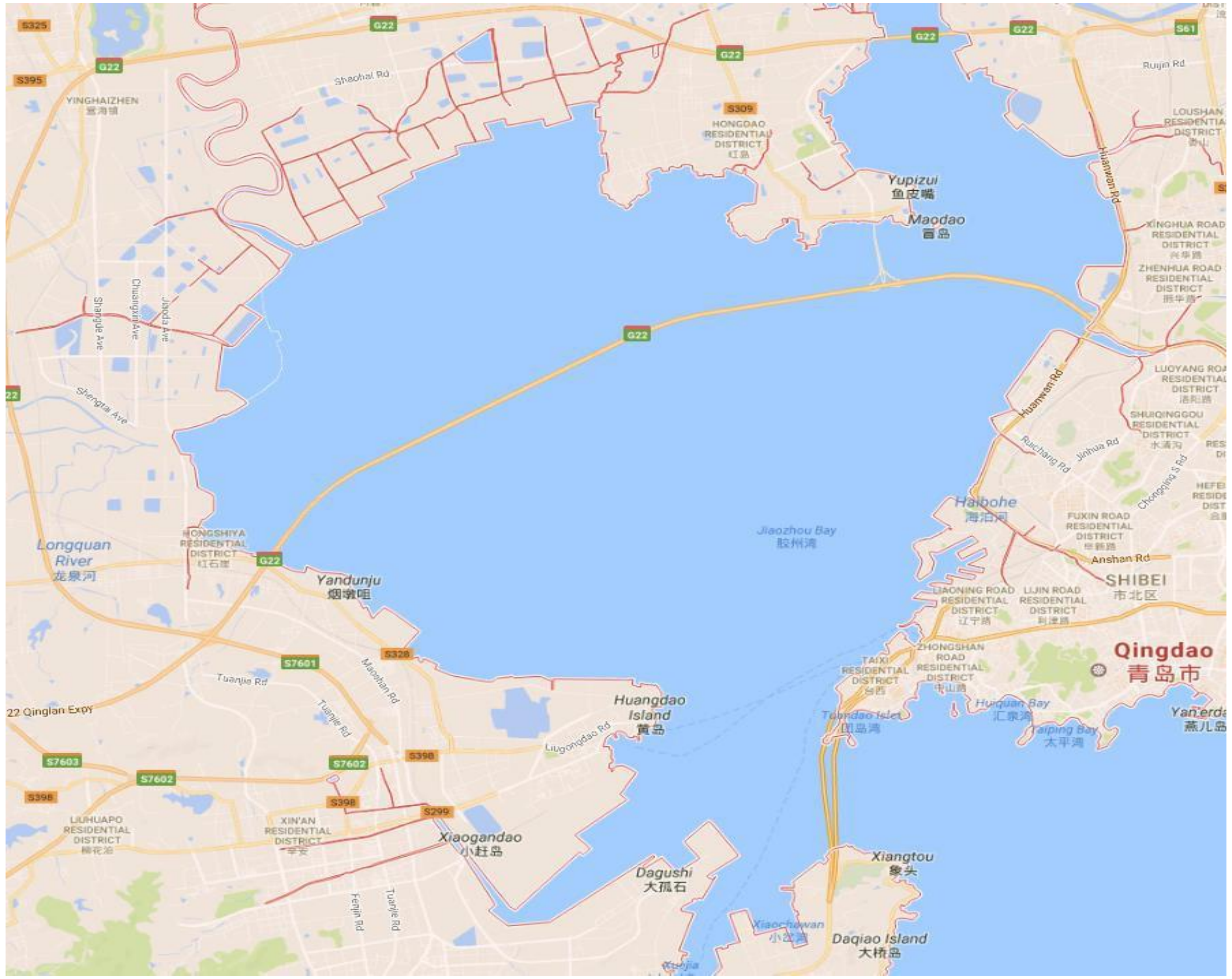
Print edition | The Americas ›
Apr 12th 2017 | SANTIAGO

TRANSANTIAGO, the Chilean capital's public-transport system, had its tenth birthday in February, but no one celebrated. Launched with much fanfare, the scheme was supposed to integrate bus and metro lines and speed up traffic. Smog-spewing yellow buses disappeared. Smart cards replaced cash.

But Transantiago is sputtering. Fare evasion is rampant, journeys are getting slower and the state has spent billions of dollars to prop up private bus operators. Passengers sometimes wait ages at stops scrawled with graffiti with no inkling of when the next bus will arrive. Espacio Público, a think-tank, calls Transantiago Chile's worst public-policy project since the country returned to democracy in 1990.



Qingdao bay bridge, China



$2.3 billion (at least)
Traffic forecast: 30,000 AADT
Actual traffic: 10,000 AADT

Demand Analysis

Absolute Documentation

Feasibility Report

Forecasting Demand

- Although accurate forecasting is very difficult to get, we use forecasting to obtain information about many subjects such as:
  - GDP and its components (e.g. consumption expenditure, residential construction)
- Traffic Forecasts
- Sales of a specific product (eg water, tickets)
- Etc.

Forecasting Demand - Prerequisites

A good forecast should:

- be consistent with other parts of the feasibility study
- be based on knowledge of the relevant past.
    - However, when underlying conditions have changed significantly, past experience may not be that helpful. Moreover, sometimes there is no past in which we rely. In this case forecast may be solely based on "expert judgments".
- consider the economic and political environment as well as any potential changes
- be timely. An accurate forecast that is too late to be acted upon may be worthless

Qualitative vs. Quantitative Forecasting

Qualitative forecasting is based on judgments of individuals or groups. The results of qualitative forecasts may be in numerical form but generally are not based on a series of historical data

Quantitative forecasting utilizes significant amounts of prior data as a basis for prediction. Quantitative techniques can be:

- Naïve forecasting projects past data without explaining future trends.
- Causal (explanatory) forecasting attempts to explain the functional relationships between the dependent variable and the independent variables.

Forecasting Techniques

There are many different forecasting techniques. The challenge is to choose the right one that is appropriate to the subject matter to be forecast .

<u>Factors in choosing the right forecasting technique:</u>

- Item to be forecast
- The relation between the value of forecast and its cost.
- Amount of historical data available
- Time allowed to prepare forecast

Categories of Forecasting Techniques

1. Expert opinion
2. Opinion polls and market research
3. Surveys of spending plans
4. Economic indicators
5. Projections
6. Econometric models

1. Expert opinion techniques

Jury of executive opinion:

- Forecasts generated by a group of corporate executives assembled together.
- The major drawback is that persons with strong personalities may exercise disproportionate influence.

1. Expert opinion techniques

The Delphi Method:

- A form of expert opinion forecasting that uses a series of questions and answers to obtain a consensus forecast, where experts do not meet.
- However, different results with different experts and ambiguity of questions are major drawback

2. Opinion Polls and Market Research

Opinion polls:

- Sample populations are surveyed to determine consumption trends.
- may identify changes in trends
- choice of sample is important
- questions must be simple and clear

Market research is closely related to opinion polling.

- Market research will indicate "not only why the consumer is or is not buying, but also who the consumer is, how he or she is using the product, and what characteristics the consumer thinks are most important in the purchasing decision."

3. Willingness to Pay (Surveys of spending plans)

The use of Willingness to Pay surveys is quite similar to opinion polling and market research in many aspects.

Seek information about “macro-type” data relating to the economy such as:

- Consumer attitudes and their effect on spending.
- Sales expectations

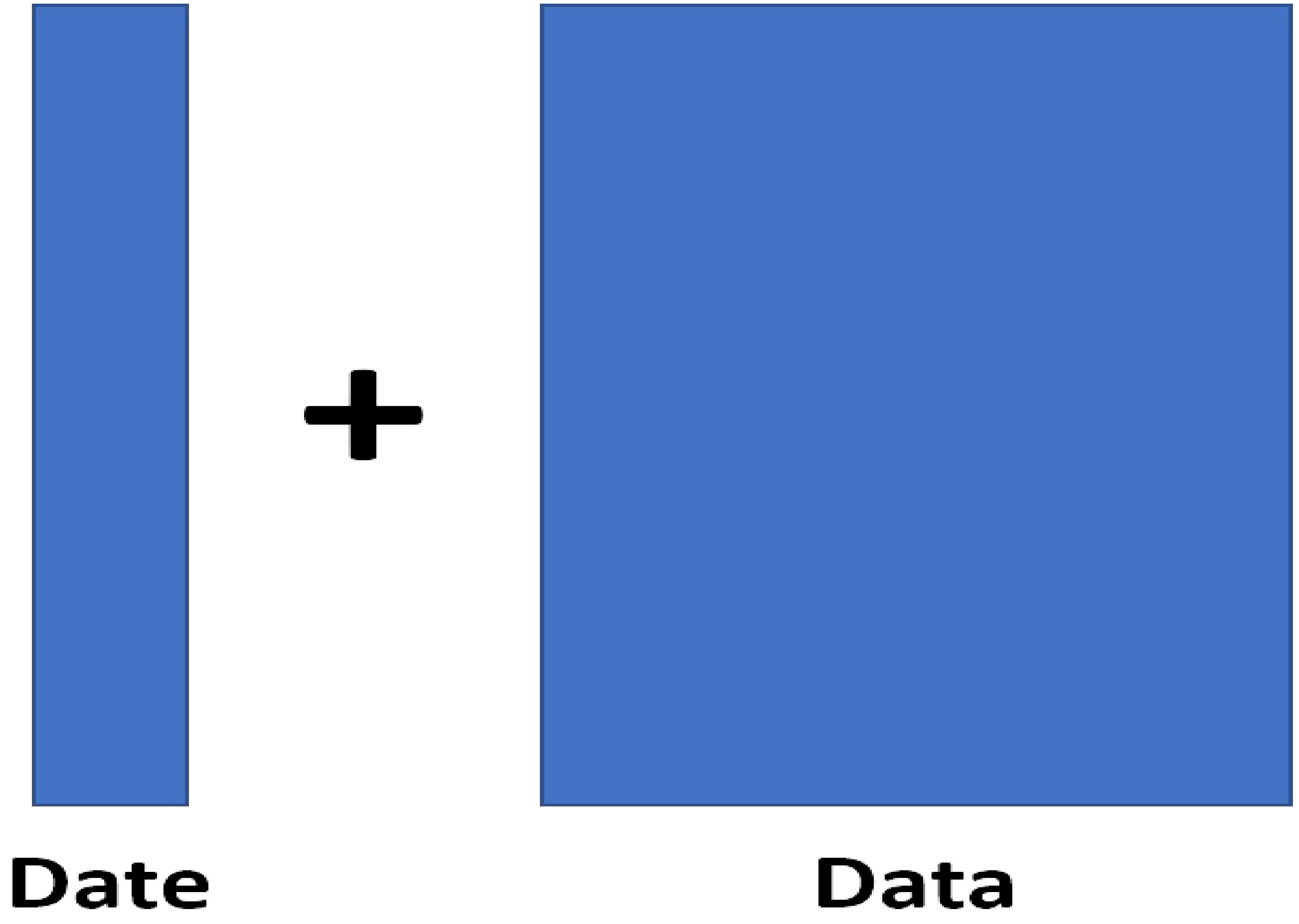
4. Economic Indicators

A barometric method of economic indicators is designed to alert for changes in economic conditions.

The success of the indicator approach to forecasting depends on the ability to identify one or more historical economic series whose direction not only correlates with, but also precedes that of the series to be predicted.

One indicator may not be very reliable, but a composite of leading indicators may be used for prediction.

5. Time Series Analysis



5. Time Series Analysis
Trend projections

A form of naïve forecasting that projects trends from past data without taking into consideration reasons for the change. It is simply assumed that past trends will continue.

Projection techniques:

- Compound growth rate
- Least squares time series projection

You should always visualize time series projections

- Plot the observations on a graph and view the shape of the data and any trends.

5. Trend projections
Compound growth rate

Forecasting by projecting the average growth rate of the past into the future.

Calculate the constant growth rate using available data, then project this constant growth rate into the future.

Provides a relatively simple and timely forecast

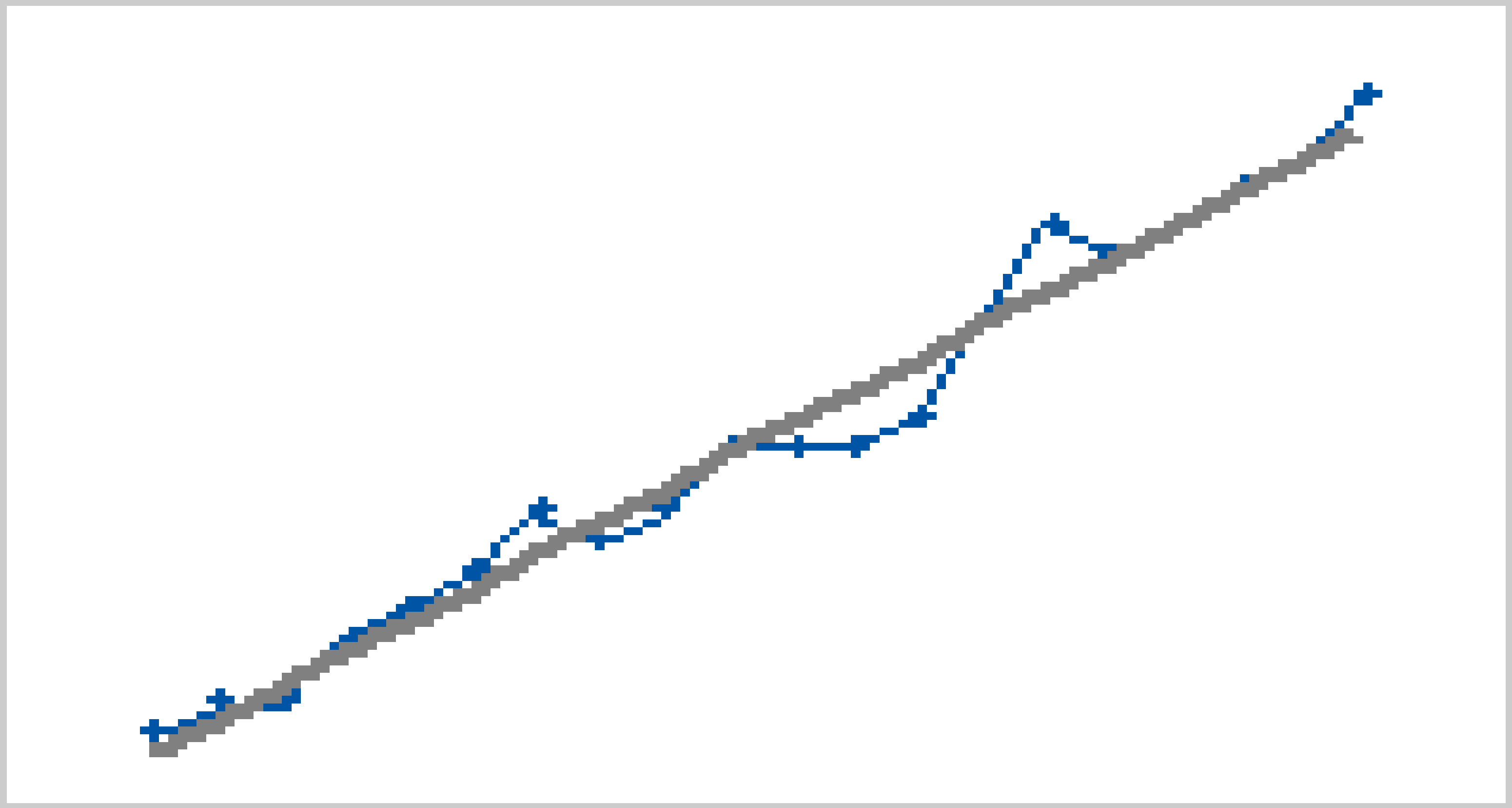
Appropriate when the variable to be predicted increases at a constant percentage

$\mathrm{FV} = PV(1+i)^t$ where i = constant growth rate

5. Time Series Analysis
Trend line

Linear

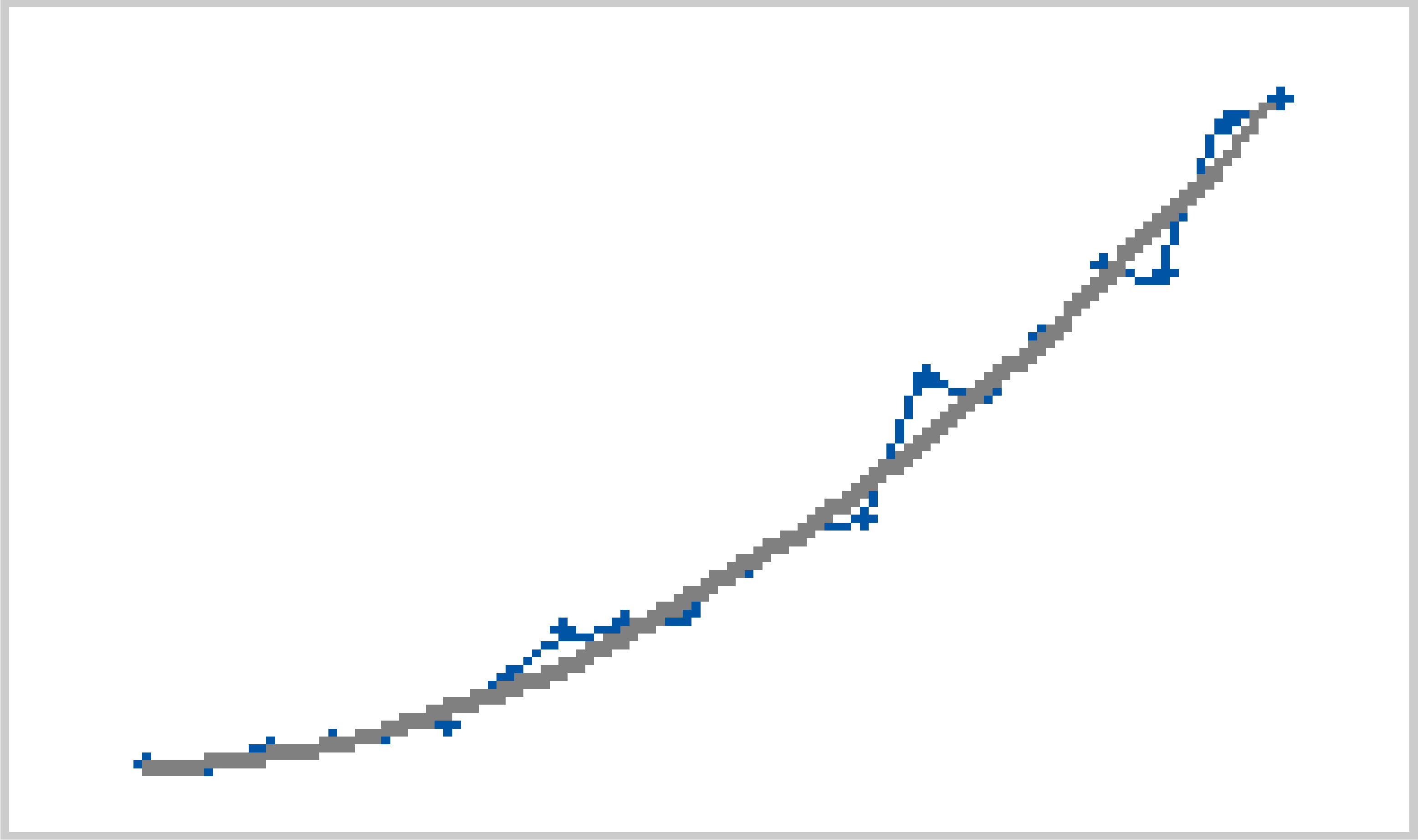
The data fits a line, which indicates that the rate of change is uniform over time. The model is $Y_t = \beta_0 + (\beta_1 * {}_t) + e_t$. In this model, β_1 represents the average change from one period to the next.



5. Time Series Analysis
Trend line

Quadratic

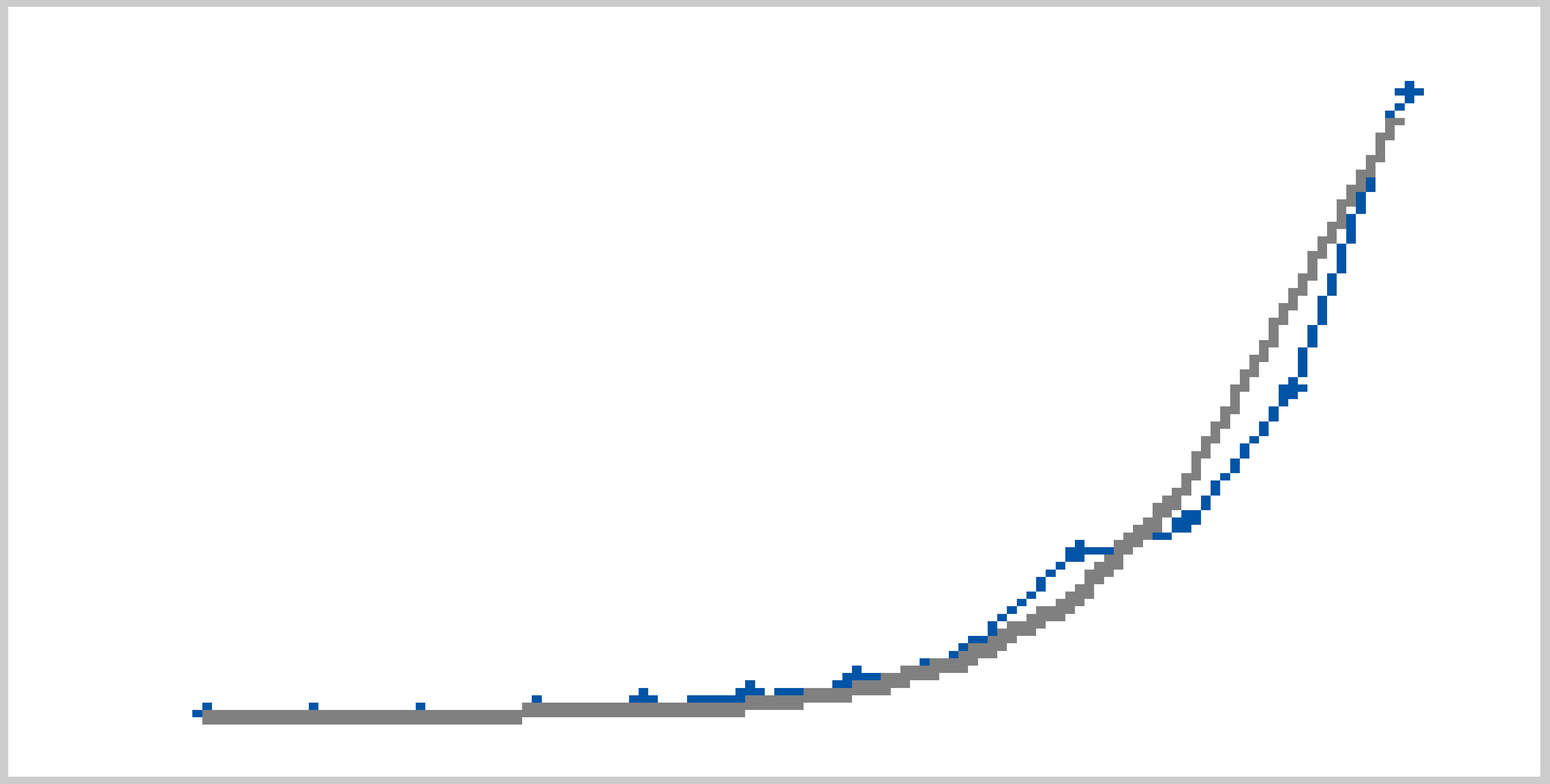
The data have a curvature, which indicates that the rate of change varies over time. The model is $Y_t = \beta_0 + \beta_1 * t + (\beta_2 * t^2) + e_t$.



5. Time Series Analysis
Trend line

Exponential growth

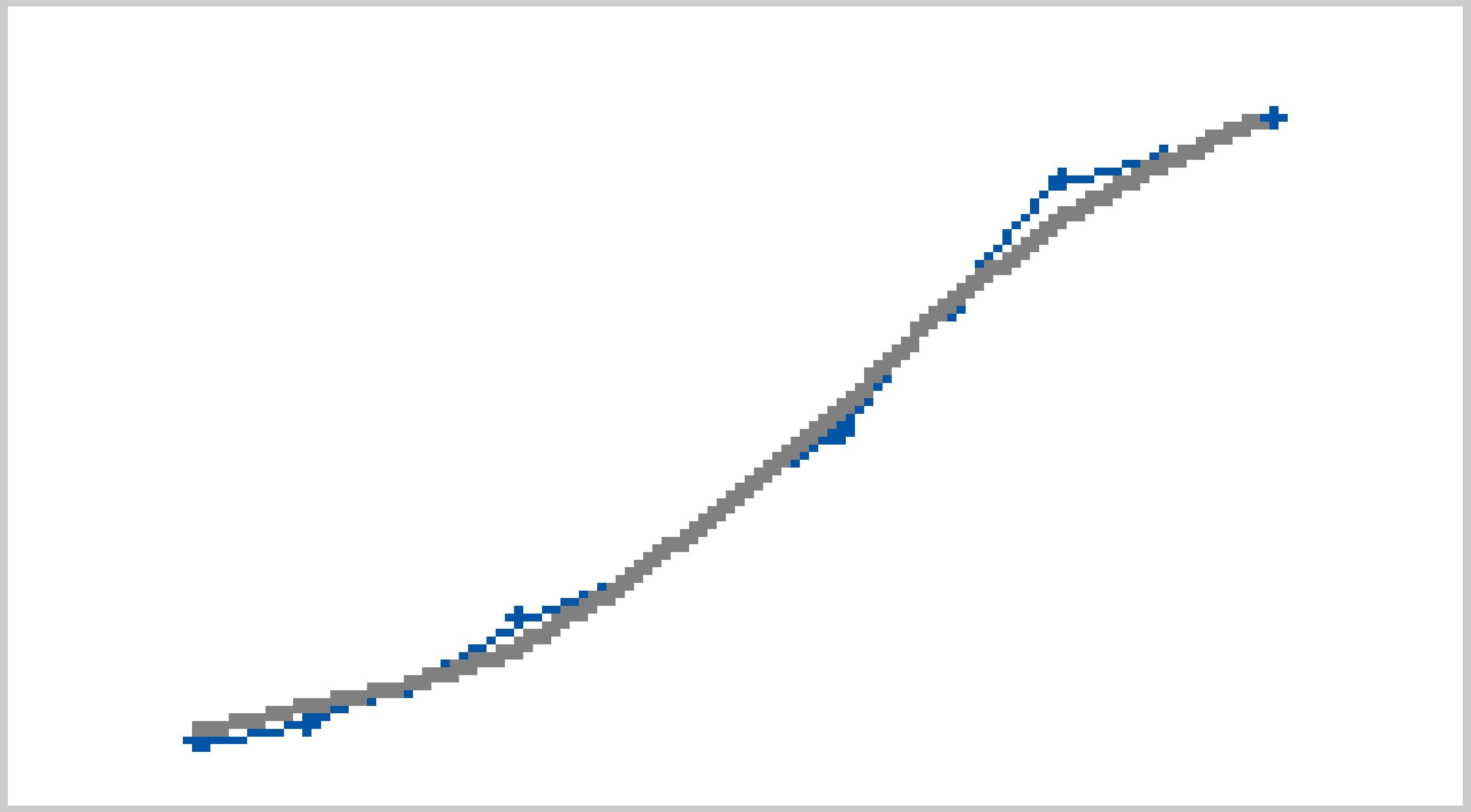
The data have a steep curvature, which indicates that the rate of change varies more quickly over time. The model is $Y_t = \beta_0 + (\beta_1^t) + e_t$.



5. Time Series Analysis
Trend line

S-Curve (Pearl-Reed logistic)

The data has an S-shape, which indicates that the direction of the change varies over time. The model is $Y_t = (10^a) / (\beta_0 + \beta_1 * \beta_2^t)$.



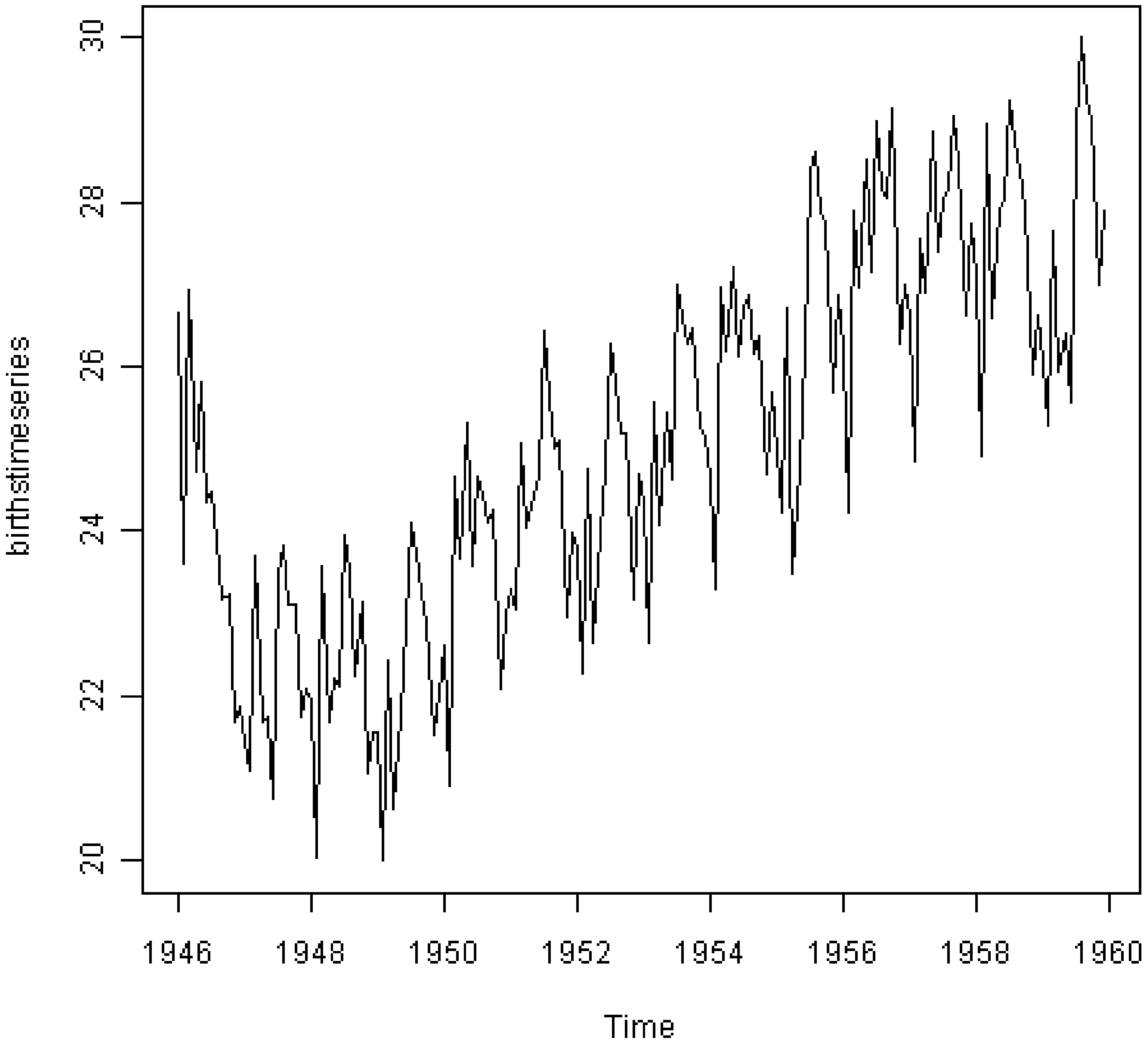
5. Time series analysis modeling

A method of forecasting from past data by using least squares statistical methods.

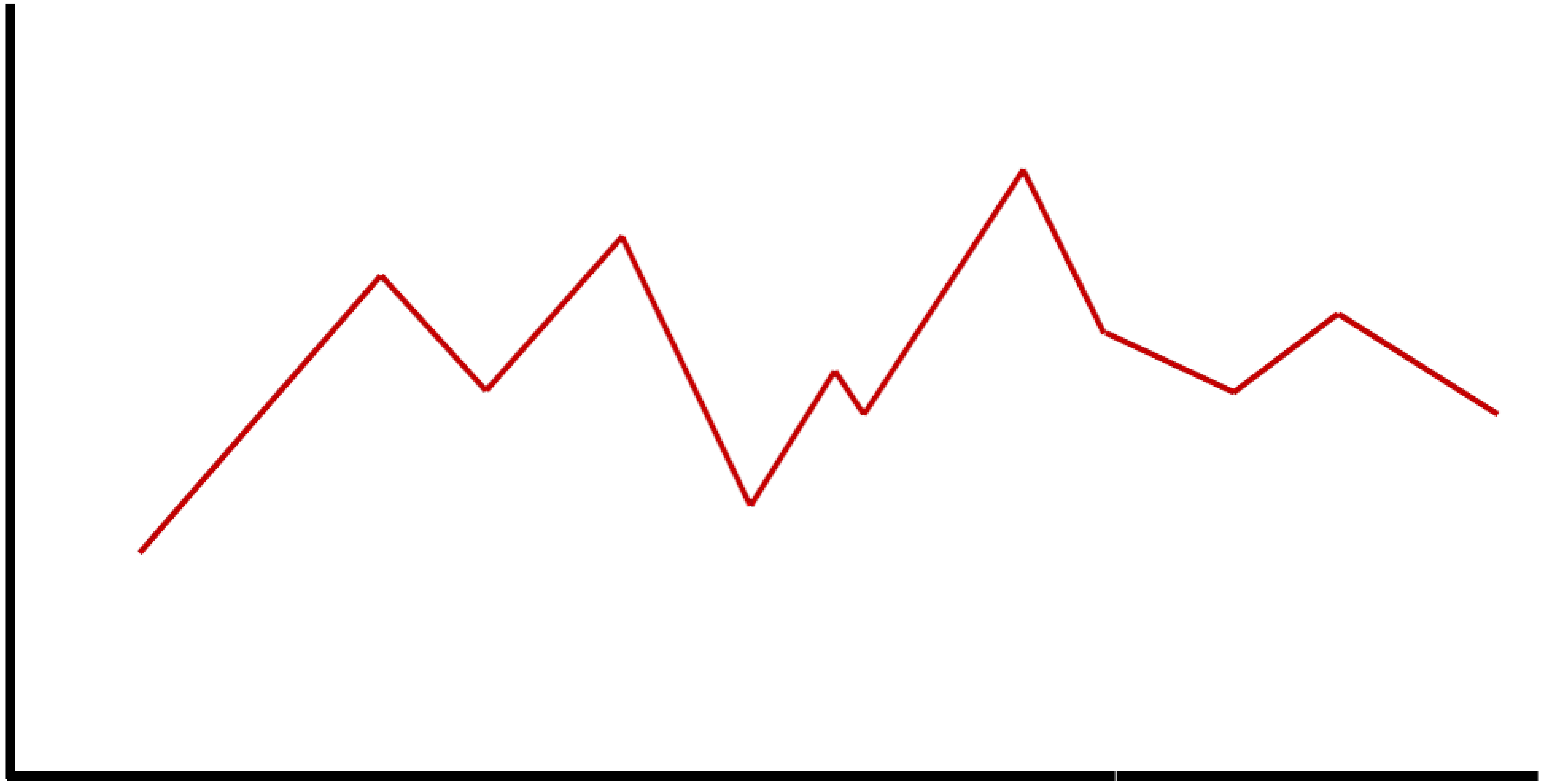
Data collected of a number of periods usually exhibit certain characteristics:

1. Trends: direction of movement of data over a relatively long period
2. Cyclical fluctuations: deviation from the trend due to general economic conditions
3. Seasonal fluctuations: a pattern that is repeated annually.
4. Irregular movements: departures from norm which may be caused by special events or may be just noise in the series.

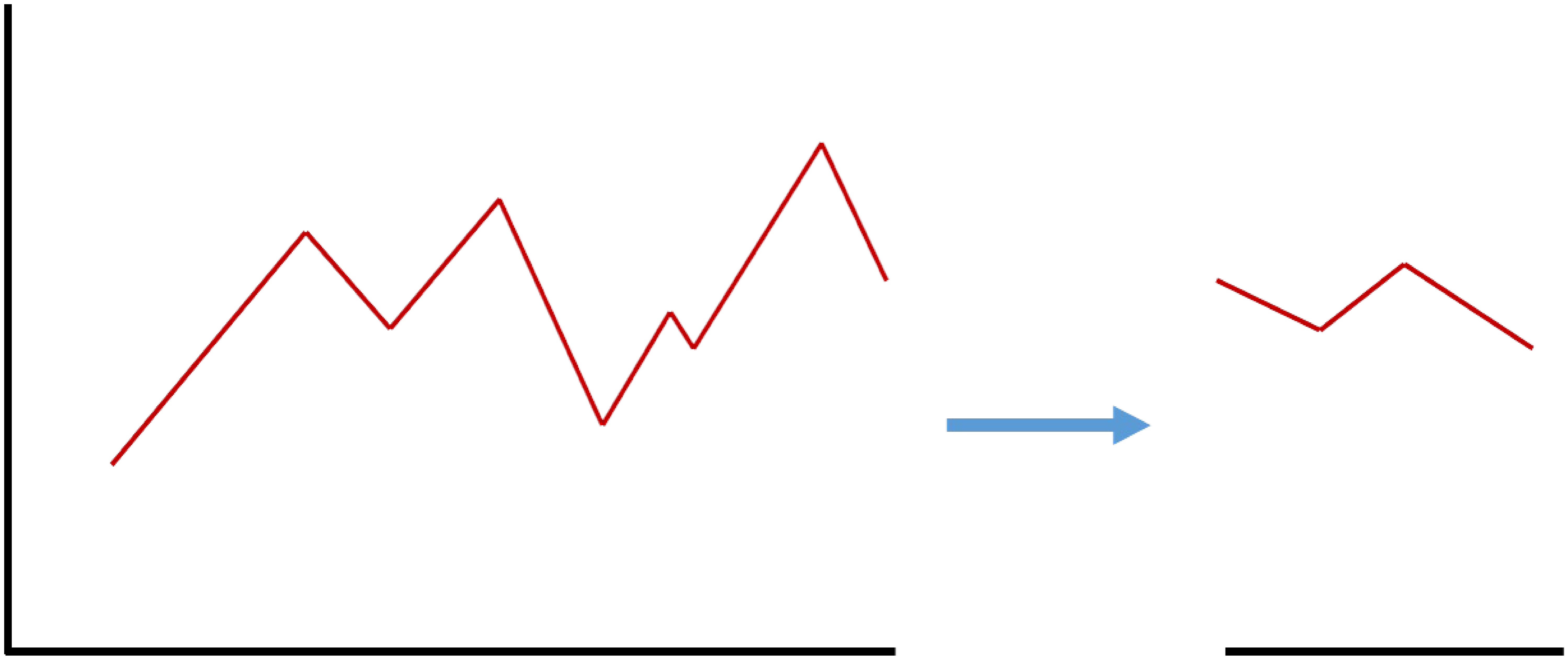
5. Time series analysis



5. Time series analysis Training vs Validation



5. Time series analysis
Training vs Validation



5. Time series analysis

Forecasting with Smoothing Techniques

- Moving Average
- Exponential Smoothing
- Double Exponential Smoothing
- ARIMA (Autoregressive Integrated Moving Average)

5. Time series analysis
How to Evaluate Forecasts?

2 Common Measures of Accuracy:

- Mean Absolute Error (MAE) ➔ units
- Mean Absolute Percentage Error (MAPE) / Symmetric MAPE ➔ %

6. Econometric Models

Causal or explanatory models of forecasting

1. Regression analysis
2. Multiple equation systems

- Endogenous variables: comparable to dependent variables of single-equation model, but may influence other endogenous variables
- Exogenous variables: from outside the system, truly independent variables

Let’s Practice!!!

Time Series

Here in this exercise you will be working with quantity demanded. There are three products - high end, low end, and specialty. The column names for the sales of these three products are MET.hi, MET.lo, and MET.sp respectively.

1. Create a date index object called dates that is 176 weeks long starting on Jan, 19, 2014
2. Sum these three regions sales together into one object called MET_t
3. Plot the MET_t object to visualize the sales of the metropolitan region of the state.
4. Split the data into both a training and validation piece with validation being all of your 2017 data.
5. Make a forecast for the first 22 weeks in 2017
6. Is it a good forecast (model)?

Let’s Poll !!!

Let’s Practice - Delphi Method

- At what economic activity should we invest?
    1. Agriculture, Forestry and Fishing
    2. Mining and Quarrying
    3. Manufacturing
    4. Electricity, Gas, Steam and Air Conditioning Supply
    5. Water Supply; Sewerage, Waste Management and Remediation Activities
    6. Construction
    7. Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles
    8. Transportation and Storage
    9. Accommodation and Food Service Activities
    10. Information and Communication
    11. Financial and Insurance Activities
    12. Real Estate Activities
    13. Professional, Scientific and Technical Activities
    14. Administrative and Support Service Activities
    15. Public Administration and Defense; Compulsory Social Security
    16. Education
    17. Human Health and Social Work Activities
    18. Arts, Entertainment and Recreation
    19. Other Service Activities
    20. Activities of Households as Employers; Undifferentiated Goods- And Services-Producing Activities of Households for Own Use
    21. Activities of Extraterritorial Organizations and Bodies

Let’s Practice - Guessing

1. Πόσα άτομα πέθαναν σε αεροπορικό δυστύχημα το 1980;

Απάντηση: [_______ , _______]

2. Πόση είναι η ολική αξία της κυπριακής υδατοκαλλιέργειας το 2012;

Απάντηση: [_______ , _______]

3. Πόσες ήταν οι Άδειες Διαμονής (μεταναστών) σε ισχύ στις 31/1/2015 στην Κύπρο;

Απάντηση: [_______ , _______]

4. Ποιο ήταν το ποσοστό των κοριτσιών στις γεννήσεις το 2014 στην Κύπρο;

Απάντηση: [_______ , _______]

5. Πόσα ήταν τα διαζύγια που εκδόθηκαν στην Κύπρο το 2014;

Απάντηση: [_______ , _______]

Steps in Project Appraisal

9 Identify the preferred project alternative - Recommendation

8 Assess affordability and sustainability

7 Analyse risks and plan for their management

6 Calculate NPV for all project alternatives

5 Value economic benefits and costs

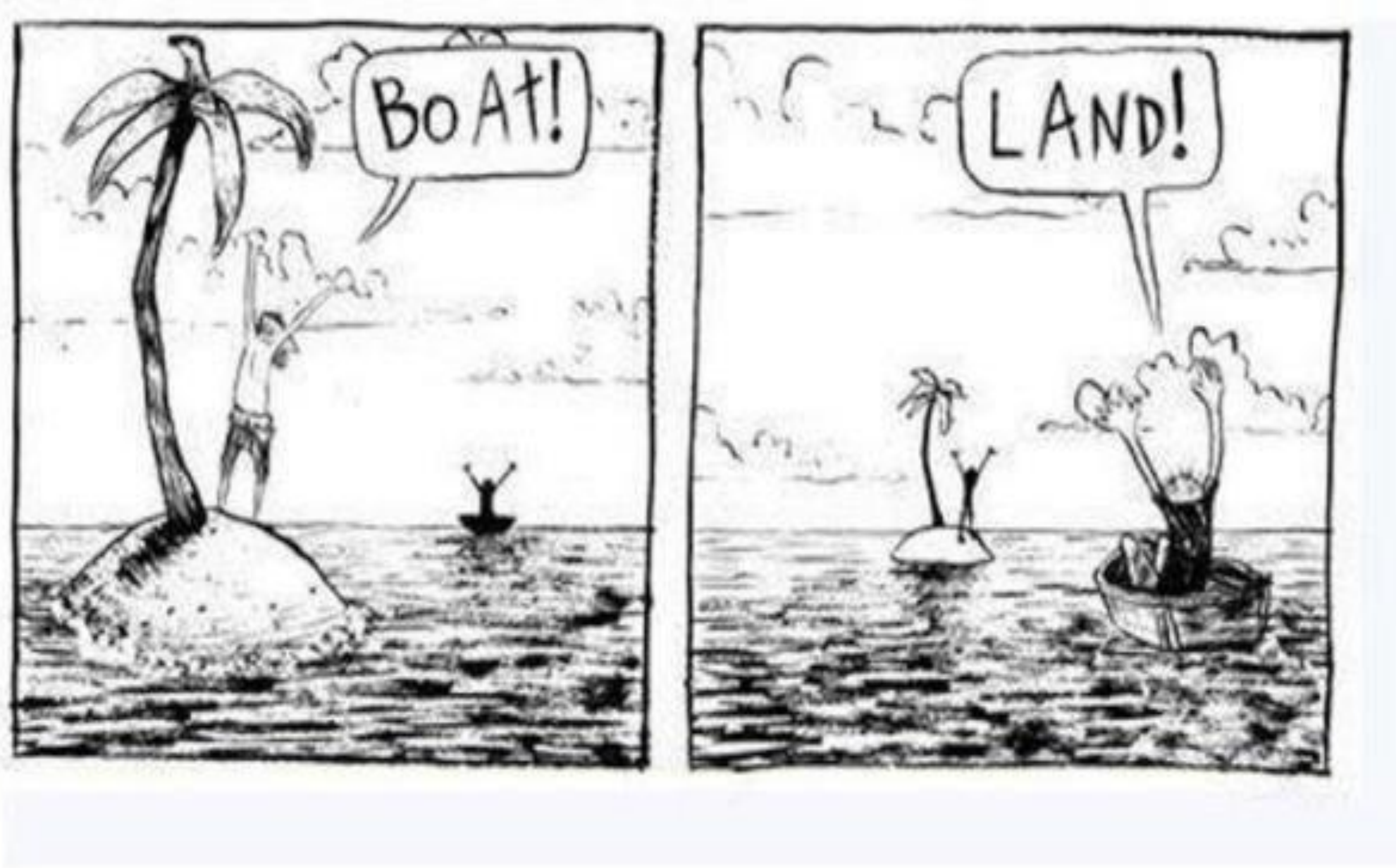
4 Identify relevant benefits and costs

3 Demonstrate the demand for the services

2 Identify and choose project alternatives

1 Define the project objectives and scope

Identify relevant benefits and costs

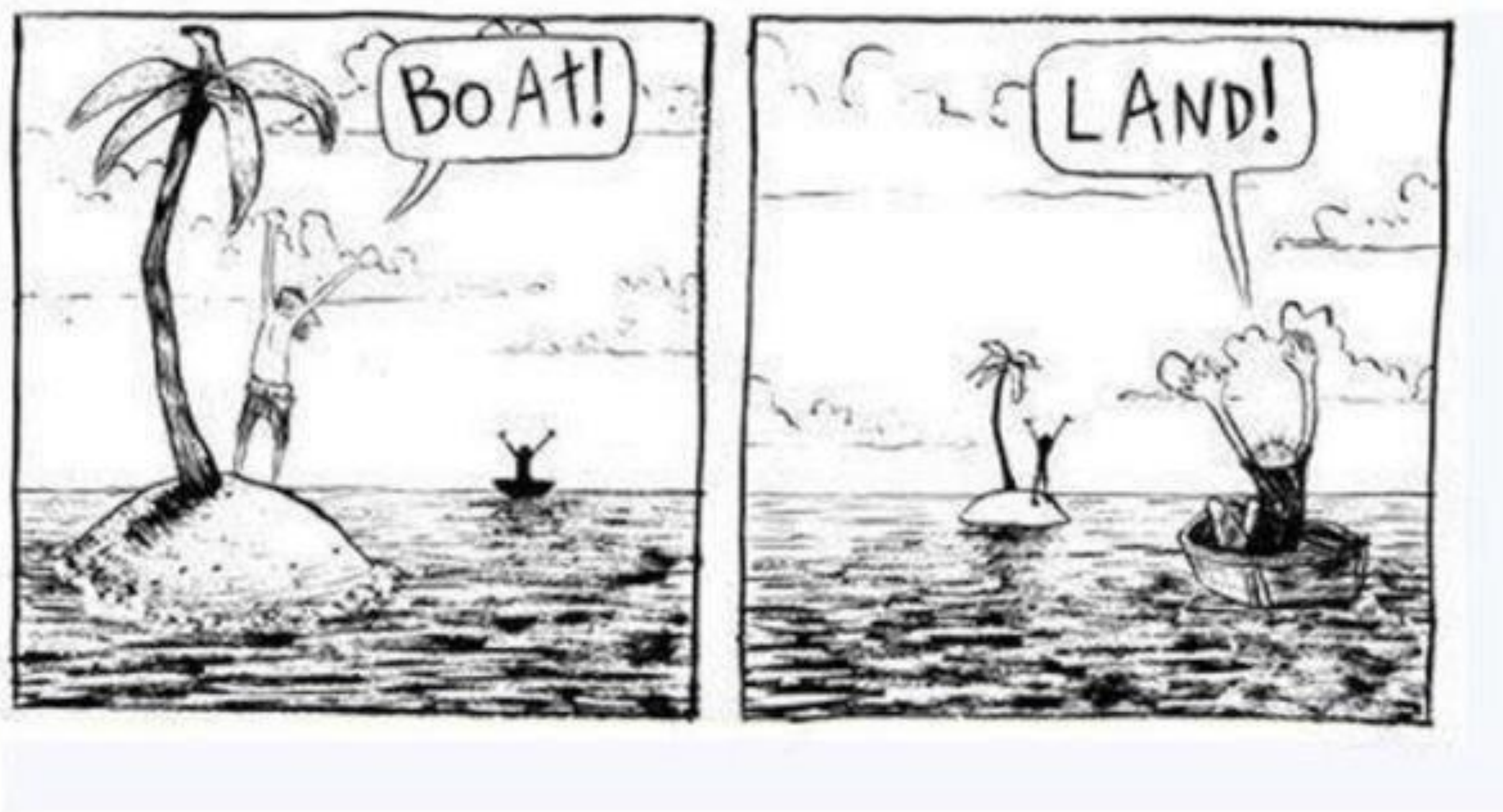


Perspective...

Economic perspective

All benefits and costs for the society as a whole

Identify relevant benefits and costs



Perspective...

Relevant to economic analysis

Relevance means that they can clearly be traced back as an effect of the project, i.e., they would not have occurred without it

Identify relevant benefits and costs

"Identifying and valuing benefits is usually the most difficult and time consuming part of an appraisal and the area where mistakes are most frequently made. Careful attention is therefore needed on identifying and valuing benefits."

Manual for Pre-Selection and Appraisal of Public Investment Projects

Government of Cyprus

Identify relevant benefits and costs

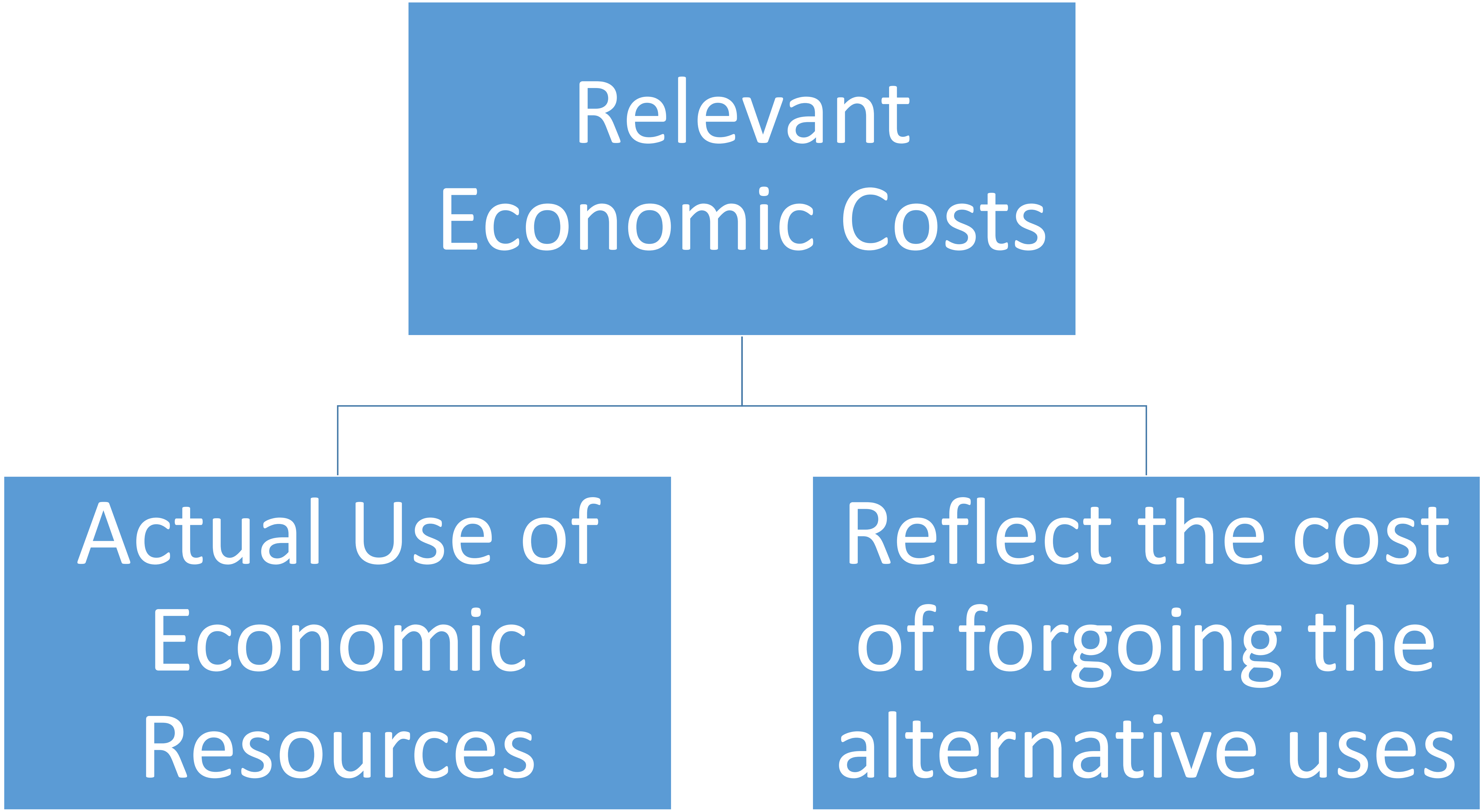
Double-counting benefits

Counting “job-creation benefits”

Ignoring displacement effects

Counting multiplier effects

Identify relevant benefits and costs



Relevant Economic Costs

Disruption during construction

Physical contingencies

Opportunity costs

Operating costs

Initial capital costs

Staff costs

Replacement costs

Negative externalities

Mitigation costs

Attributable administrative overheads

Relevant Economic Costs - Initial Capital Costs

- Purchases of land and buildings
- Infrastructure and works
- Purchases of equipment, furniture, vehicles, computer hardware and software
  - Although intangible, software is classified as a fixed asset and software purchase or development must be treated like any other capital investment in a Project Appraisal.
- Installation and implementation costs
- Development costs, including staff costs and consultancy and other professional fees
- Testing
- Training
- Contingency costs

Relevant Economic Costs – Physical Contingencies

Physical contingencies are allowances to cover unforeseen circumstances during project implementation or operation

- i.e increased construction costs due to unexpectedly difficult ground conditions.

Whenever contingencies form part of the expected costs of a project, they should be included as an economic cost.

Relevant Economic Costs – Opportunity Costs

Opportunity cost is the value of the choice of a best alternative cost while making a decision.

Consequently, we refer to opportunity costs of publicly owned capital assets, like land, buildings, equipment and vehicles that will be employed in the project.

Relevant Economic Costs – Disruption During Construction

Disruption during construction: this cost should not be overlooked, particularly for major projects in congested areas.

Relevant Economic Costs – Replacement Costs

Replacement costs for any capital assets that come to the end of their lives during the analysis period.

- This may be an important consideration for project alternatives that involve extending the lives of existing assets or using lower specifications.

Relevant Economic Costs – Staff Costs

Staff costs recurring throughout the analysis period. These are the costs of employees' time to the employer and must include pensions, social charges and allowances , as well as basic salaries. Relevant staff may include those involved in:

- Management
- Day-to-day operations
- Support
- Ongoing training

Relevant Economic Costs – Operating Costs

Operating costs recurring throughout the analysis period including:

- Maintenance costs (routine and periodic)
- Licensing and support costs for software
- Bureau services (data processing and on-line services)
- Leasing and rental costs (relevant for project alternatives to new construction and ownership)
- Recurring contingency costs
- Utilities and Services

Relevant Economic Costs – Attributable Administrative Overheads

Attributable administrative overheads:

some overhead costs may occur because of the project, but they must be demonstrably attributable to the project and not costs that would be expected to be the same with or without the project.

Relevant Economic Costs – Negative Externalities

Negative externalities:

These are negative effects on third parties, which do not affect the operating entity or the direct beneficiaries of the project, such as increased noise and air pollution from traffic using a new road or landscape degradation from unsightly construction.

Special note:

Greenhouse gas emissions are negative externalities with international ramifications. Project promoters must take account of the Government of Cyprus's international position on limiting carbon emissions and consider the most appropriate way of dealing with this cost when implementation and operation of the project is expected to generate an increase in emissions.

Relevant Economic Costs – Mitigation Costs

Mitigation costs

a consequence of negative externalities may be the need to build mitigation measures into the project design, particularly for severely negative environmental impacts or even for adverse social impacts.

Costs that are not relevant to Economic Analysis

- Inflation
  - economic analysis is performed using values expressed in real terms
- Depreciation
  - has no direct economic effect
- Capital charges or interest payments
  - Capital charges are an accounting device reflecting the opportunity cost of funds tied up in owning capital assets
  - Interest payments are a financial transfer within the economy
- Sunk costs
  - In this case the resources have already been committed and have no alternative use

Annex 2

Manual for Pre-Selection and Appraisal of Public Investment Projects

Government of Cyprus

Let’s Practice!!!

Case Study
Identify Relevant Benefits and Costs of a:
1. Road Construction
2. Hospital / Health Capital Investment

Steps in Project Appraisal

9 Identify the preferred project alternative - Recommendation

8 Assess affordability and sustainability

7 Analyse risks and plan for their management

6 Calculate NPV for all project alternatives

5 Value economic benefits and costs

4 Identify relevant benefits and costs

3 Demonstrate the demand for the services

2 Identify and choose project alternatives

1 Define the project objectives and scope

Value of Economic Benefits and Costs Basic Principles

1. Proportionality
   - Financially significant ≥ €5.0 million
   - It is not generally expected, that the same depth of research and analysis will be carried out for a project costing, say, €5.0 million as for a project costing, say, euro €150.0 million.
   - Exceptions apply!!!!

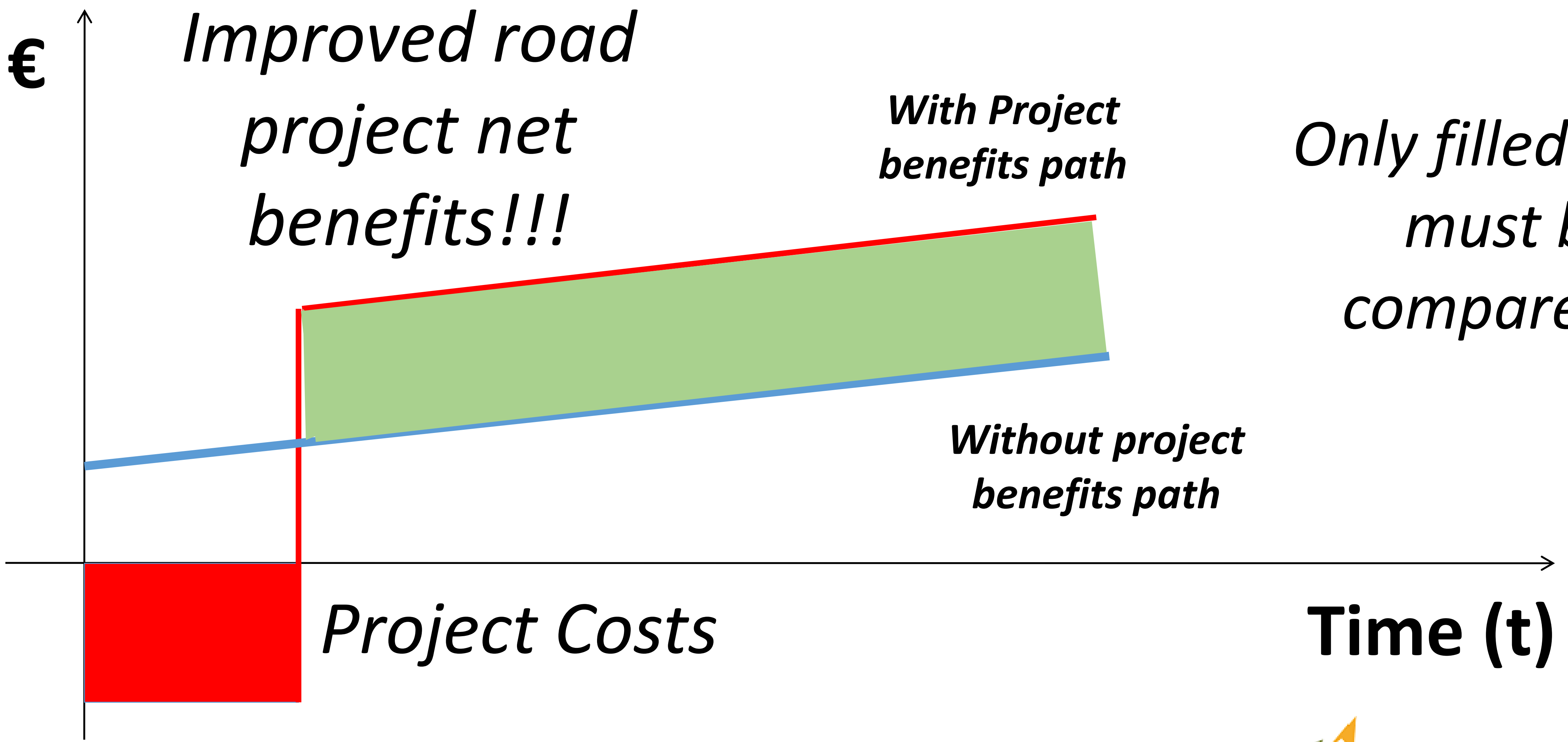
Value of Economic Benefits and Costs Basic Principles

1. Proportionality
2. Incremental Benefits and Costs

Incremental Benefits and Costs

The "With " and "Without" Project Scenario

The project must be appraised on the basis of incremental analysis i.e. a road improvement project.



Only filled areas must be compared!!!

Value of Economic Benefits and Costs Basic Principles

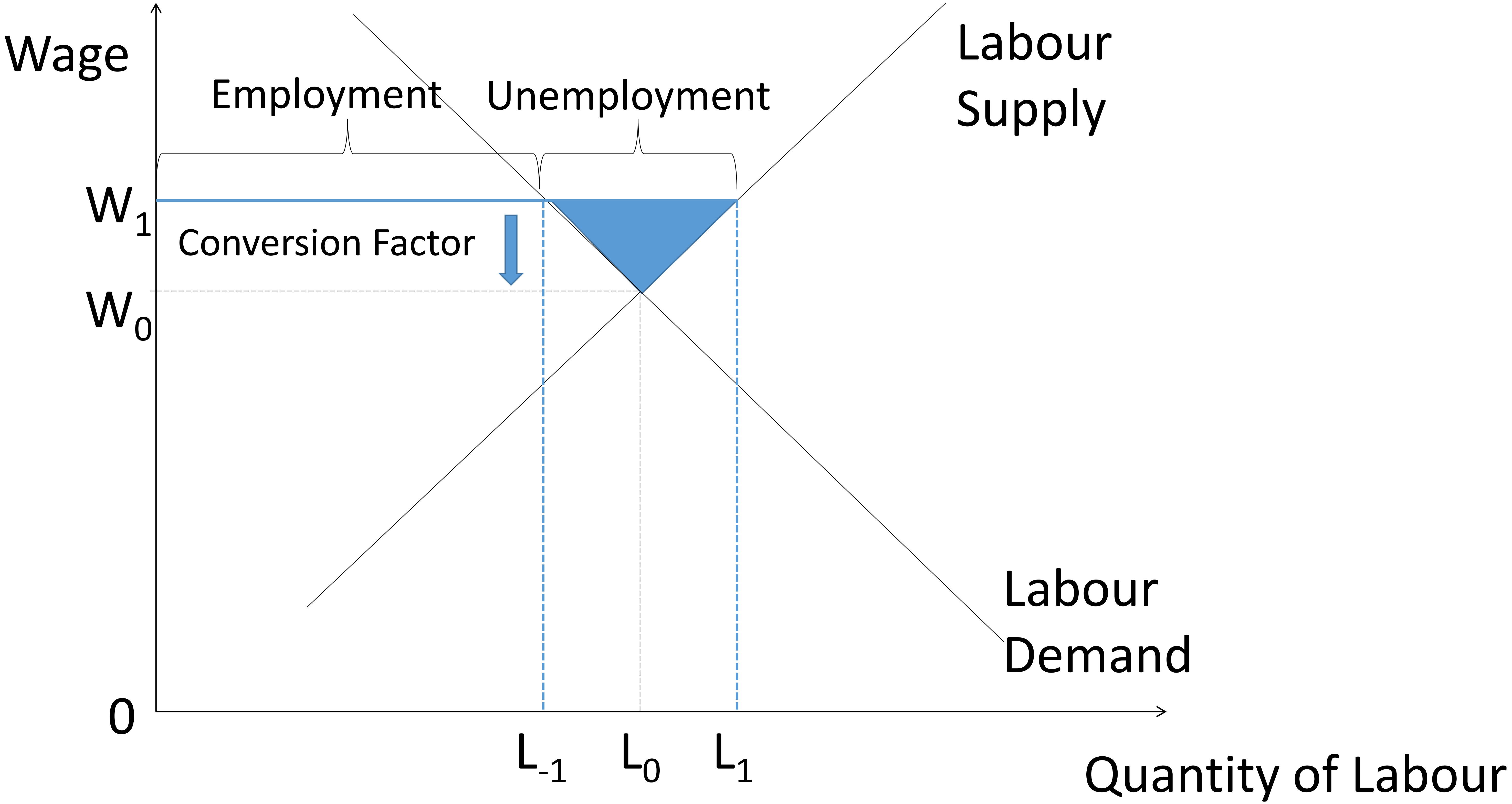
1. Proportionality
2. Incremental Benefits and Costs
3. Use of market prices

Value of Economic Benefits and Costs Basic Principles

- Use of market prices
  - Default assumption
  - Good reflection of opportunity costs
  - Adjustments may often have to be made
    - Theoretical Example: Cost of Labour

Shadow Prices

Market Prices



Costs identification and valuation at economic prices

The Commodity Specific Conversion Factors (CSCF)

A conversion factor can be used to express the relationship between financial prices and economic value, if the distortions are a fixed proportion of the financial price.

Conversion factors are used to convert the financial cash-flow into the economic resource statement for the economic appraisal.

$$CSCF_i = \frac{\text{Economic Value}}{\text{Financial Price}}$$

Value of Economic Benefits and Costs Basic Principles

1. Proportionality
2. Incremental Benefits and Costs
3. Use of market prices
4. Use of real prices

Value of Economic Benefits and Costs Basic Principles

- Use of real prices
  - Common base year
  - Real price movements unrelated to changes in the general price level, may be taken into account where there is strong evidence to support this
    - i.e increasing real rental costs
  - All assumptions concerning real price trends must be stated explicitly in the Feasibility Study!!!

Value of Economic Benefits and Costs
Basic Principles

1. Proportionality
2. Incremental Benefits and Costs
3. Use of market prices
4. Use of real prices
5. Adjustment for taxes, subsidies and transfers

Value of Economic Benefits and Costs Basic Principles

- Adjustment for taxes, subsidies and transfers
  - Indirect Taxes (i.e VAT)
  - Subsidies
  - Social Transfers (i.e social security benefits)
- Do not entail the consumption or creation of economic resources
  - excluded from the valuation of benefits and costs
- Thus, market prices used to value benefits and costs are expressed net of indirect taxes and subsidies and the value of social transfers are not included as benefits or costs

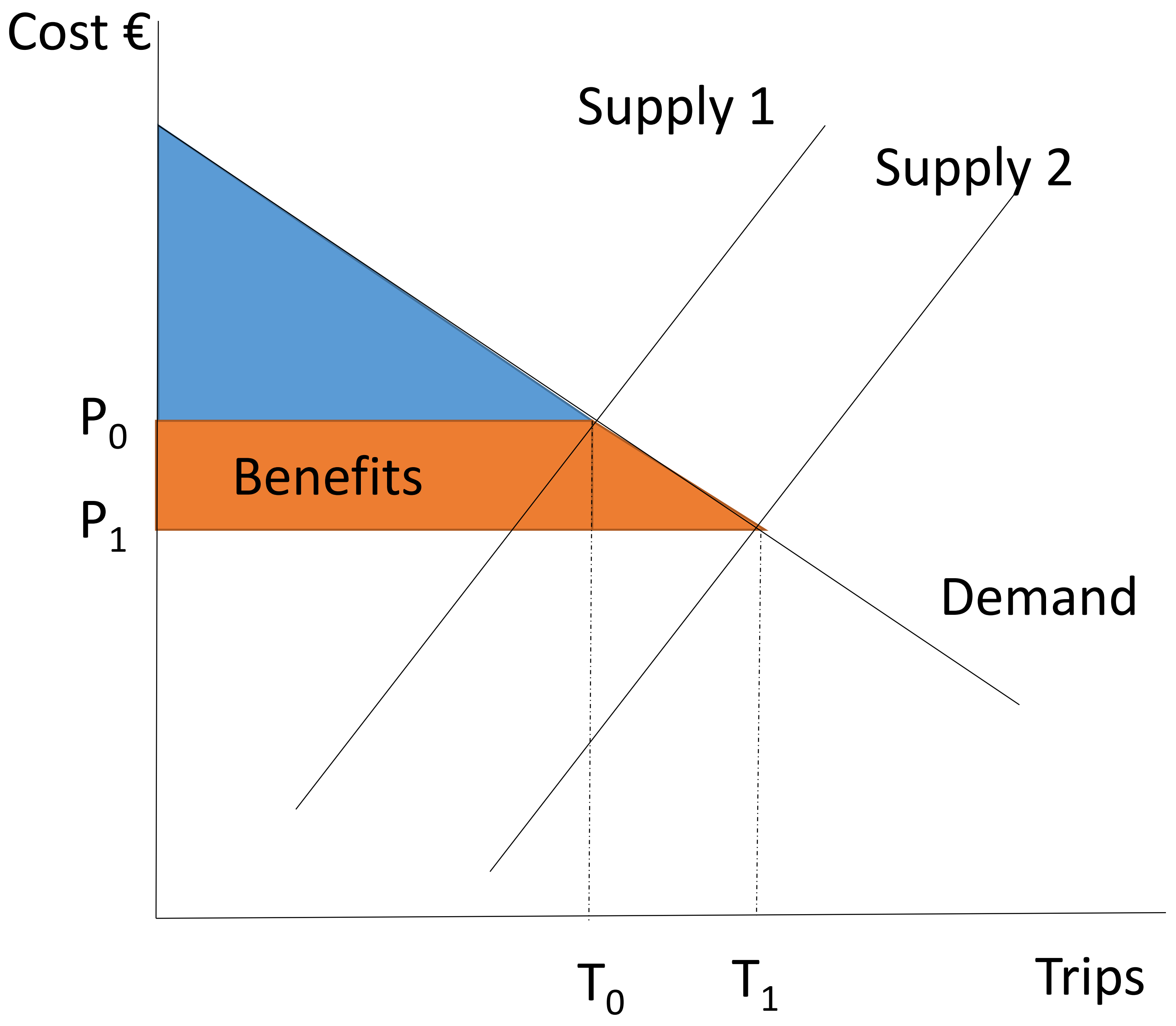
Value of Economic Benefits and Costs
Basic Principles

1. Proportionality
2. Incremental Benefits and Costs
3. Use of market prices
4. Use of real prices
5. Adjustment for taxes, subsidies and transfers
6. Rule of ½

Value of Economic Benefits and Costs Basic Principles

- Rule of ½
  - Where a project will generate significant extra demand the benefits accruing to new users must be treated in a different way to those occuring to existing users
  - This effect is approximated by taking benefits to generated demand as being half the average benefit going to existing users

Value of Economic Benefits and Costs Basic Principles - Rule of ½



$$Benefits = \frac{1}{2}(P_0 - P_1) * (T_0 - T_1)$$

Value of Economic Benefits and Costs Basic Principles

1. Proportionality
2. Incremental Benefits and Costs
3. Use of market prices
4. Use of real prices
5. Adjustment for taxes, subsidies and transfers
6. Rule of ½

Let’s Practice!!!

Cost correction (valuation) at economic prices

- Find the shadow price of gasoline price in Cyprus?

Standard Conversion Factor (SCF) European Guide

- $SCF = \frac{\text{M+X}}{\text{M+X+TM}}$
- M is the total value of imports at shadow prices
- X is the total value of exports at shadow prices
- TM is the total value of duties on import

Example

- M= EUR 25,000 million, X= EUR 20,000 million, TM= EUR 500 million
- $\mathrm{SCF} = \frac{25000 + 20000}{25000 + 20000 + 500} = 0.989$

Value of Economics Benefits

- The most difficult and resource intensive part of project appraisal
- Benefit estimates should be based on real or estimated market prices for the services

Value of Economics Benefits

- Where no market exists, alternative means of estimating values for benefits should be used.

Willingness to pay

1. Revealed preference techniques

2. Stated preference techniques

Revealed preference techniques

Based on actual observable choices and from which actual resource values can be directly inferred

Revealed Preference Techniques
Hedonic Pricing

Hedonic pricing

- Involves deriving values by decomposing actual market prices into their constituent characteristics to obtain insights into willingness to pay for benefits for which there is no directly observable market.
- An example would be using the difference between residential property prices at varying distances from an environmental amenity, e.g., a park or lake, to estimate the inherent utility of such amenities , and hence the benefit of creating similar new amenities.

Revealed Preference Techniques
Travel Cost Analysis

- Uses estimates of the total costs people are willing to incur to access free amenities as a minimum estimate of what they are willing to pay. So, for example, the generalized travel costs, including the value of travel time, that people bear in travelling to a park or recreation facility, give an indication of the value they place on the amenities provided.
- This can then be used in valuing the potential welfare gain from similar new facilities. It is a minimum estimate because users will experience a gain in welfare in excess of their travel costs (otherwise they would not be willing to travel to and use the facility) i.e. consumer surplus.
- Application of this technique requires the collection of good survey data on distance travelled, journey times, mode of transport, frequency of use and income from a representative sample of users of existing facilities similar to the proposed project.

Let’s Practice!!!

Hedonic Pricing

Hedonic Pricing

- $Final\ Price = Cost\ of\ House + Land\ Cost$

Assumptions (so far)

- House Cost = €50,000
- House price (rural area) = €60,000
- House price (urban area) = €100,000

- $60000 = 50000 + Land\ Cost \Rightarrow Land\ Price = 10000$
- $100000 = 50000 + Land\ Cost \Rightarrow Land\ Price = 50000$

Hedonic Pricing

- $Final\ Price = Cost\ of\ House + Land\ Cost$

Assumptions (so far)

- House Cost = €50,000
- House price (rural area) = €60,000
- House price (urban area) = €100,000
- Solar Panel installation = €10,000

House No.	Price	Features
1	70,000	Rural + Solar
2	60,000	Rural
3	100,000	Close to City
4	100,000	Close to City

Hedonic Pricing

House No.	Date of Sale	Price	Features	Solar	Rural	Urban
1	01-02-2015	70,000	Rural + Solar	1	1	0
2	05-03-2015	60,000	Rural	0	1	0
3	06-07-2015	100,000	Urban	0	0	1
4	30-08-2015	100,000	Urban	0	0	1

$$Final\ Price = Cost\ of\ House + 10000 * Rural + 50000 * Urban + 10000 * Solar$$

Travel Cost Analysis

- Suppose that individuals A and B have the same money income, have the same tastes, and face the same set of prices for all goods and services except that of access to a National Park. Individual A lives further away from the Park than Individual B and hence incurs a higher travel cost per visit. There is no admission charge to enter the Park.

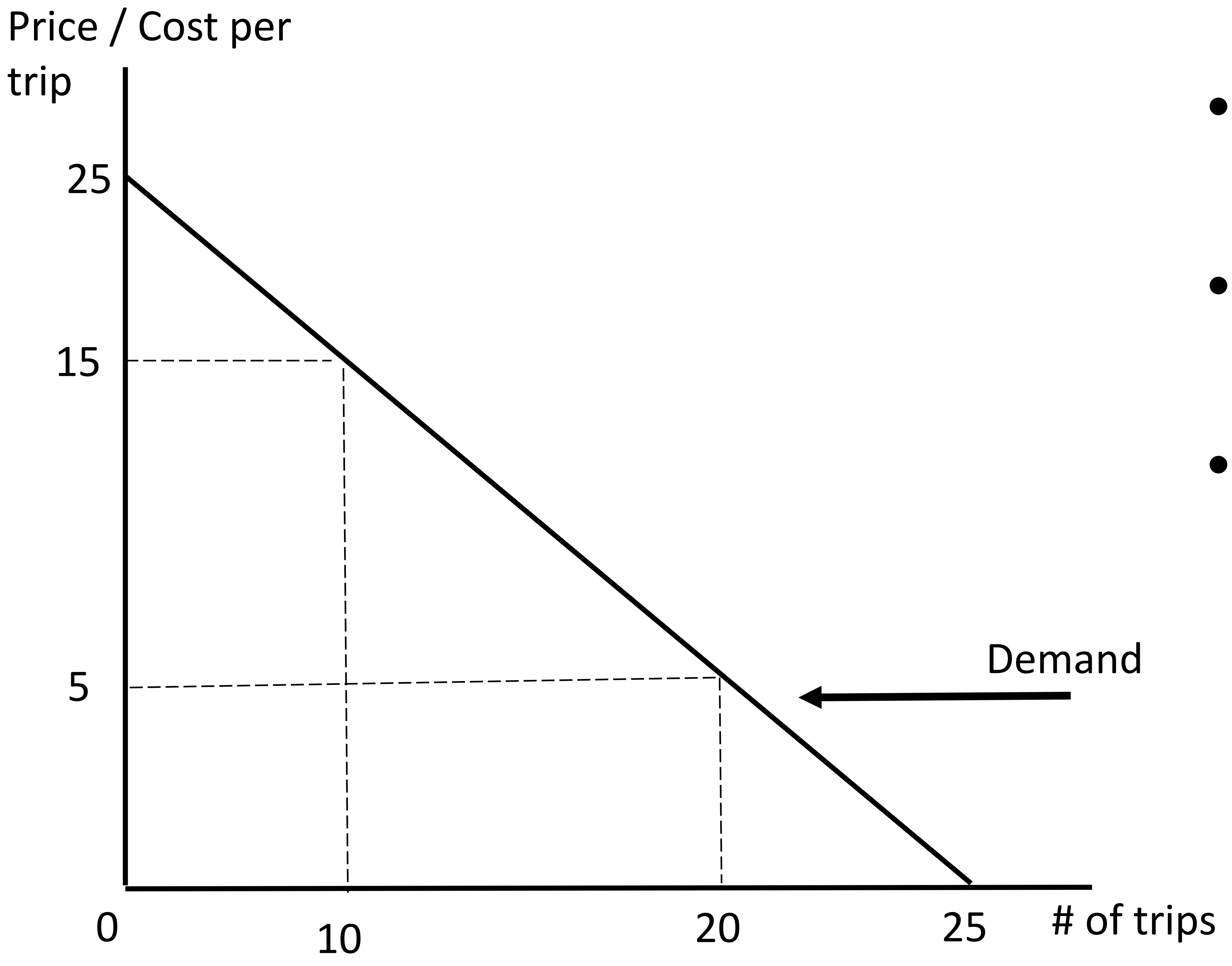
Individual Travel	Cost per Visit (€)	Visits per Year
A	15	10
B	5	20

Travel Cost Analysis

You are asked to calculate:

1. how much consumer surplus does Individual A receive per annum from her use of the Park?
2. how much consumer surplus does Individual B receive per annum from his use of the Park?
3. what is the value of the annual benefits to A and B from their use of the Park?

Travel Cost Analysis



- Consumer surplus for A = 0.5(10×10) = €50
- Consumer surplus for B = 0.5(20×20) = €200
- Total consumer surplus = €50 + €200 = €250

Stated preference techniques

Respondents are directly asked about their willingness to pay for a good or service

Stated Preference Techniques
Contingent Valuation

- Contingent valuation studies either ask open-ended questions concerning the maximum amount a potential user would be willing to pay for a given service delivered through the project, or offer a constrained choice of values from which the respondent is asked to choose.

Stated Preference Techniques
Contingent Valuation - Example

Questions about the Willingness to Pay

- “What is the most you would be willing to pay for . . . ?”
  - Total freedom as regards the answer
  - Problem if respondent has no experience from using the good or service
- “What is the most you would be willing to pay for . . . ?”

□€5□€10□€15□€20□€5□€30□€35□€40□€45□€50

- Average Individual Willingness to Pay (AWTP)
- $AWTP = \frac{\sum_{i=1}^{n} w_i}{n}$
- $Confidence\ Interval: [AWTP - t_{\frac{a}{2},n-1} * \frac{s}{\sqrt{n}}, AWTP + t_{\frac{a}{2},n-1} * \frac{s}{\sqrt{n}}]$

Stated Preference Techniques
Contingent Valuation - Example

To obtain adequate answers from the respondent, many studies prefer to employ the dichotomous choice approach advocated by the National Oceanic and Atmospheric Administration, also known as the NOAA method

"Assume that you have to pay $25 for the project . . .

Would you be in favor of its implementation?□yes□ no"

- The NOAA method, the computation of the average willingness to pay implies the use of logit or probit econometric models (alas, not supported by Excel)

Stated Preference Techniques
Choice modeling

- Choice modeling presents potential users with a series of alternatives involving trade-offs between costs and benefits from which they are required to indicate a preference. This method is better for valuing specific attributes of a service than for valuing the service as a whole. It attempts to get around the potential biases that can arise from asking direct questions concerning hypothetical payments, but in doing so adds more complexity.

Stated Preference Techniques
Choice modeling - Example

Suppose that we would like to estimate the economic value of a natural park. The attributes and levels chosen to describe the options are presented in the next slide. For each attribute, levels are arranged in increasing order, quantitatively or qualitatively. For instance, €15 represents the third highest level of additional annual tax for the creation of the park, out of four possible payments.

Stated Preference Techniques
Choice modeling - Example

Attributes	Levels	No.
Additional Tax per year	€5	1
	€10	2
	€15	3
	€20	4
Amenities	Basic (toilets)	1
	Medium (toilets and picnic area)	2
	High (toilets, picnic area and exercise station)	3
Recreational facilities	Basic (jogging)	1
	Medium (jogging and children playground)	2
	Not inside the park	1
Camping	Inside the park, in unorganized campsite	2
	Inside the park, in organized campsite	3

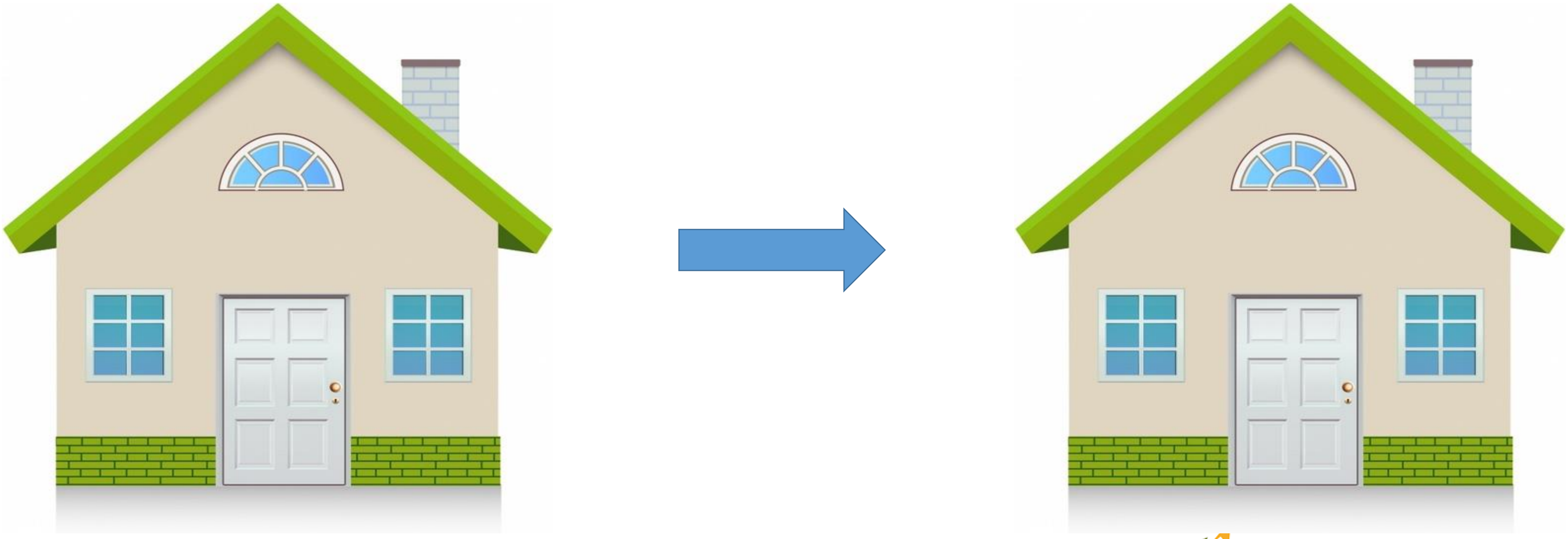
Stated Preference Techniques Choice modeling - Example

Attributes	Option 1	Option 2	Option 3 (Status quo)
Additional tax per year	€20	€5	€0
Amenities	High (toilets, picnic area and exercise station)	Medium (toilets and picnic area)	No amenities
Recreational facilities	Basic (jogging)	Medium (jogging and children playground)	No recreational facilities
Camping	Not inside the park	Inside the park, in organized campsite	No camping site
Which option would you prefer?			

Benefits Transfer Method

- Estimates economic values by transferring existing benefit estimates from studies already completed for another location or issue.

€300,000 €300,000



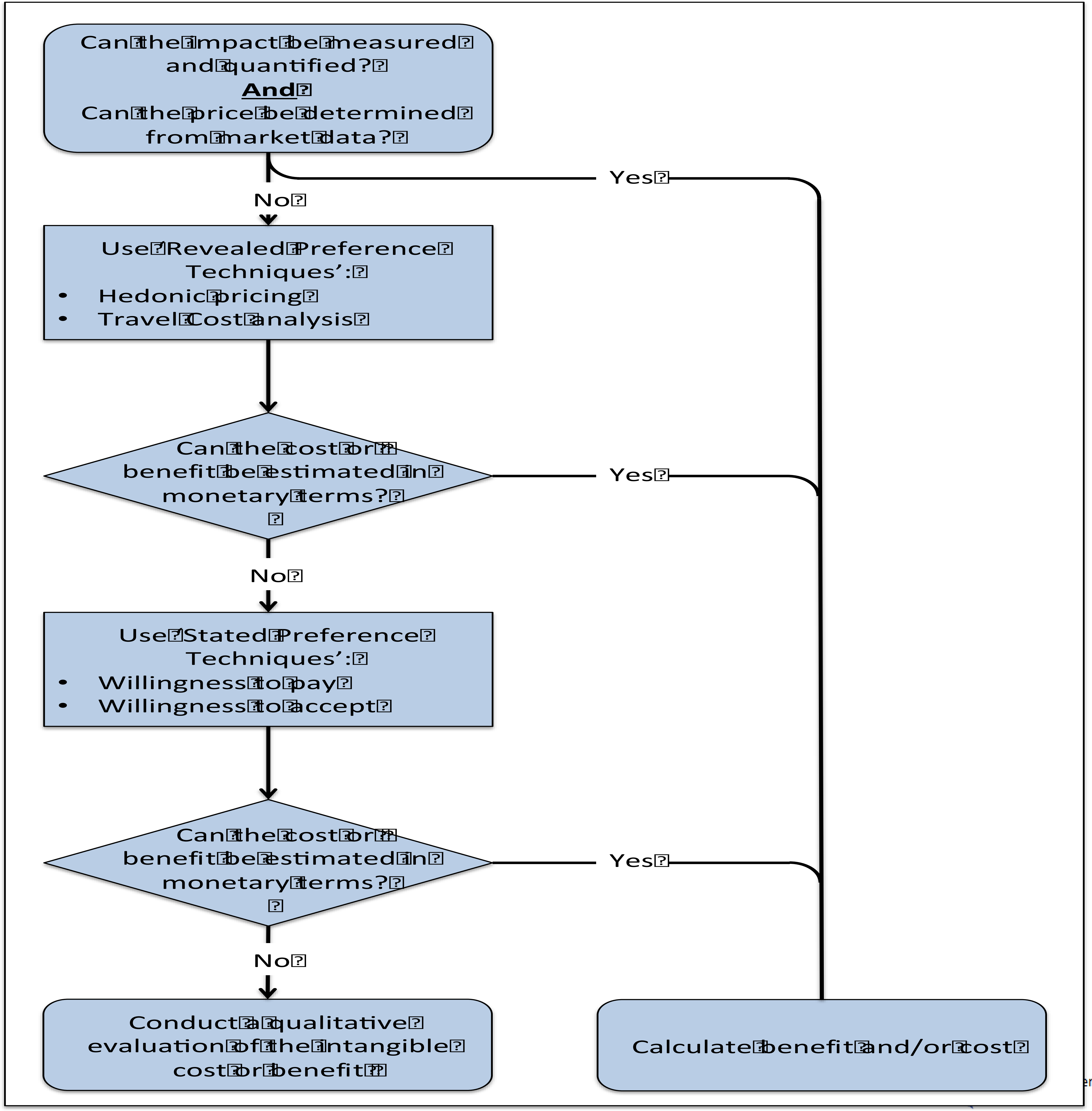
Application of the Benefit Transfer Method

- The first step is to identify existing studies or values that can be used for the transfer.
- The second step is to decide whether the existing values are transferable. The existing values or studies would be evaluated based on several criteria, including:
    1. Is the service being valued comparable to the service valued in the existing study/studies? Some factors that determine comparability are similar types of sites (e.g., size of park), similar quality of sites (e.g., water quality and facilities), and similar availability of substitutes (e.g., the number of parks nearby).
    2. Are characteristics of the relevant population comparable? For example, are demographics similar between the area where the existing study was conducted and the area being valued? If not, is data available to make adjustments?

Application of the Benefit Transfer Method

- The third step is to evaluate the quality of studies to be transferred. The better the quality of the initial study, the more accurate and useful the transferred value will be. This requires the professional judgment of the researcher.
- The final step (Step 4) is to adjust the existing values to better reflect the values for the site under consideration, using whatever information is available and relevant. The researcher may need to collect some supplemental data in order to do this well. The researcher might adjust the values from the first study by applying demographic data to adjust for the differences in users.

Estimating Non-Monetary Benefits and Costs


Can the impact be measured and quantified?
And
Can the price be determined from market data?
Yes
No
Use 'Revealed Preference Techniques':
• Hedonic pricing
• Travel Cost analysis
Can the cost or benefit be estimated in monetary terms?
Yes
No
Use 'Stated Preference Techniques':
• Willingness to pay
• Willingness to accept
Can the cost or benefit be estimated in monetary terms?
Yes
No
Conduct a qualitative evaluation of the intangible cost or benefit
Calculate benefit and/or cost

Let’s Practice!!!

Estimating Non-Monetary Benefits and Costs

Absolute Documentation

Feasibility Report

In contrast to….

“Εκτιμάται ότι η σχετική αναμενόμενη ανάπτυξη τεχνογνωσίας των κυπριακών επιχειρήσεων θα μπορούσε να ανέλθει σε [€XXX.XXX], με χρονική υστέρηση 1 έτους.”

Μελέτη Κόστους Οφέλους

που παραδόθηκε στο Γραφείο μας

Steps in Project Appraisal

9 Identify the preferred project alternative - Recommendation

8 Assess affordability and sustainability

7 Analyse risks and plan for their management

6 Calculate NPV for all project alternatives

5 Value economic benefits and costs

4 Identify relevant benefits and costs

3 Demonstrate the demand for the services

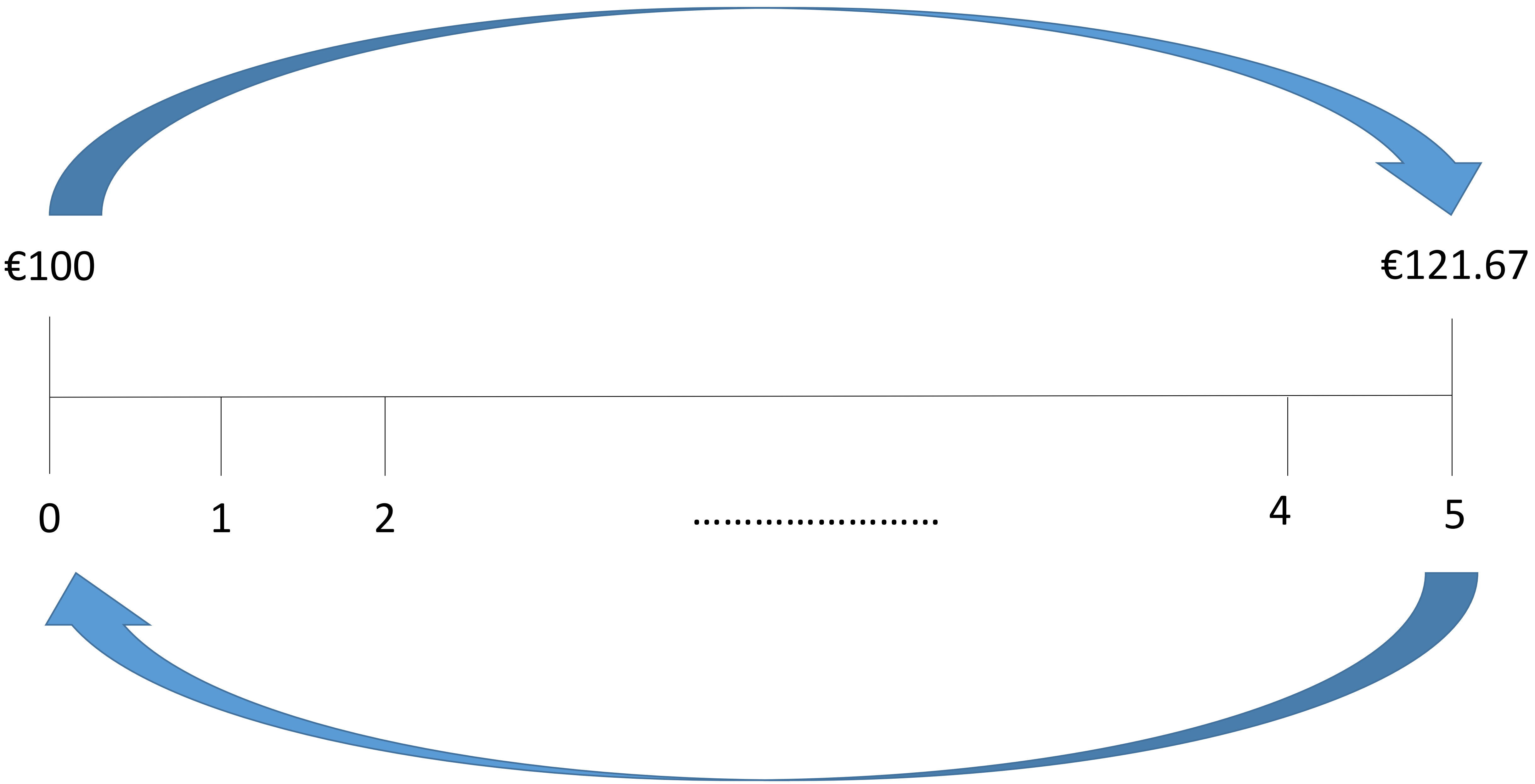
2 Identify and choose project alternatives

1 Define the project objectives and scope

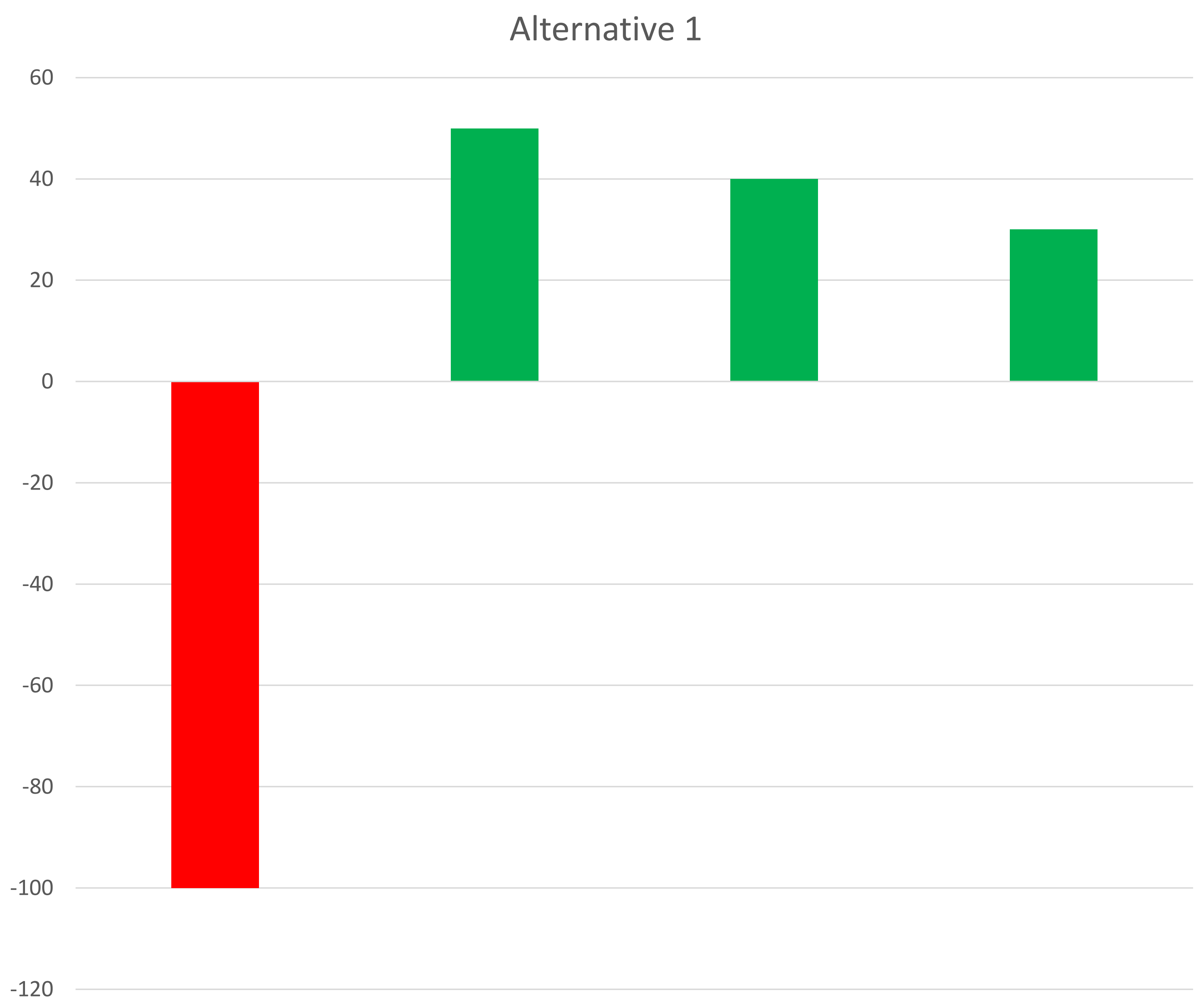
Why Discount?

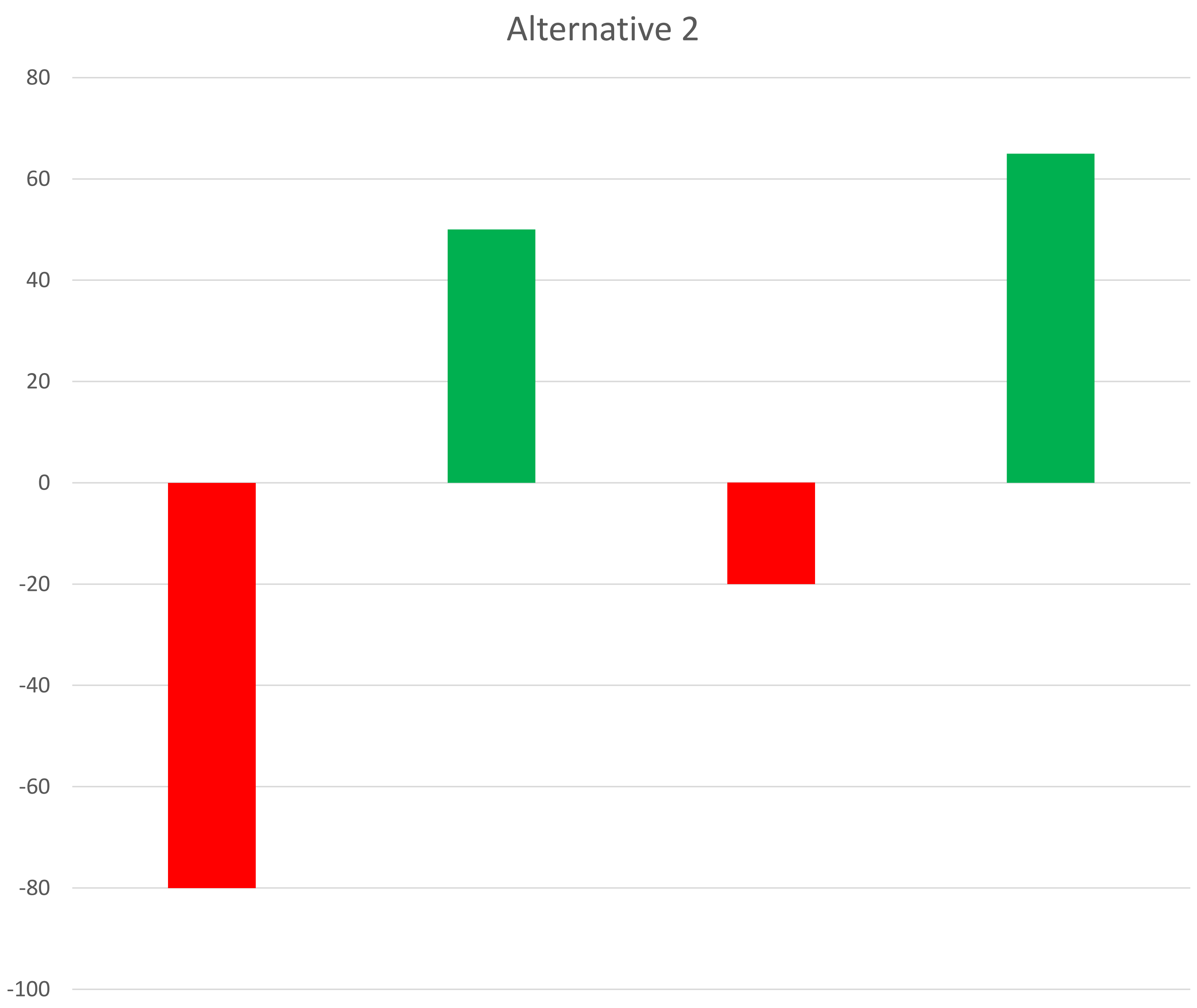
Would you like to receive €100 today or €100 in 5 years?

4% Discount rate



Discount rate = ???



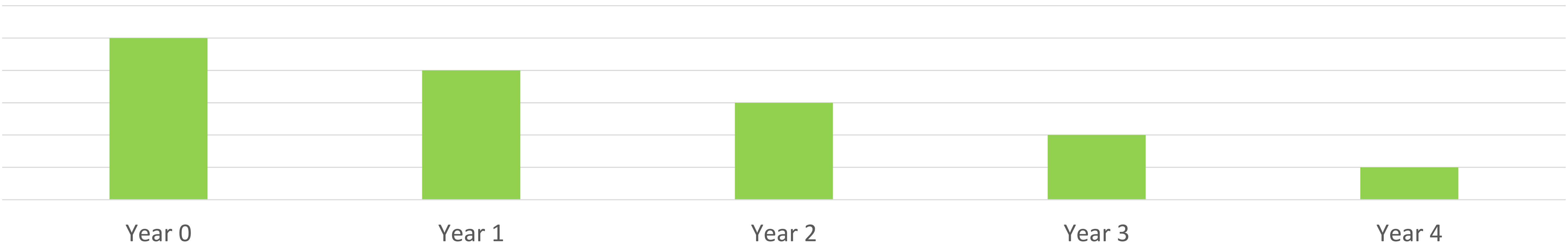


Economic / Social Discount Rate vs Financial Discount Rate

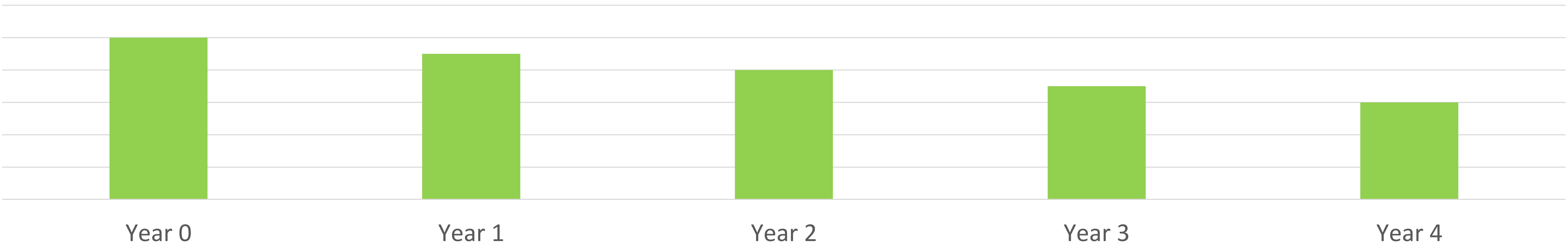
- Financial Discount Rate
  1. Competition return
  2. Cost of Capital
- Weighted Average Cost of Capital
  - if for a project 40% of the investment comes from a bank @4% and 60% from private investors @12% then
  - WACC = 0.40*4% + 0.6*12% ➔
  - WACC = 8.80%

Calculate NPV for all project alternatives

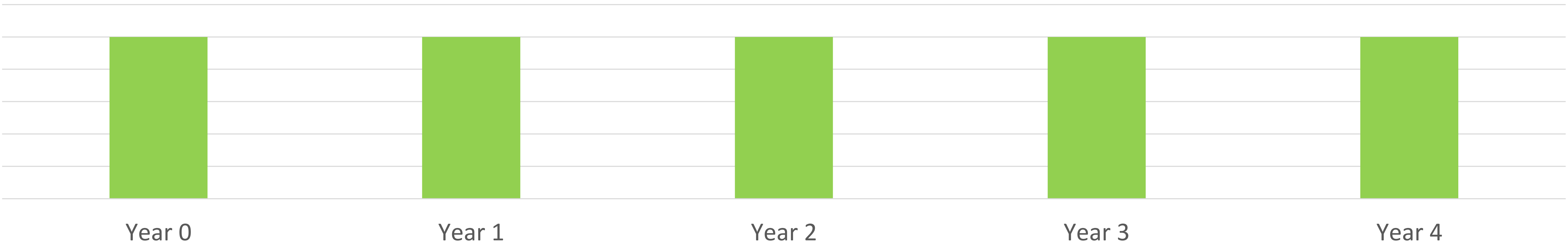
	Social Discount Rate
Risk-free rate	2.5%
Risk premium	1.5%
Risk-adjusted rate	4.0%



Discount Rate = 20%



Discount Rate = 5%



Discount Rate = 0%

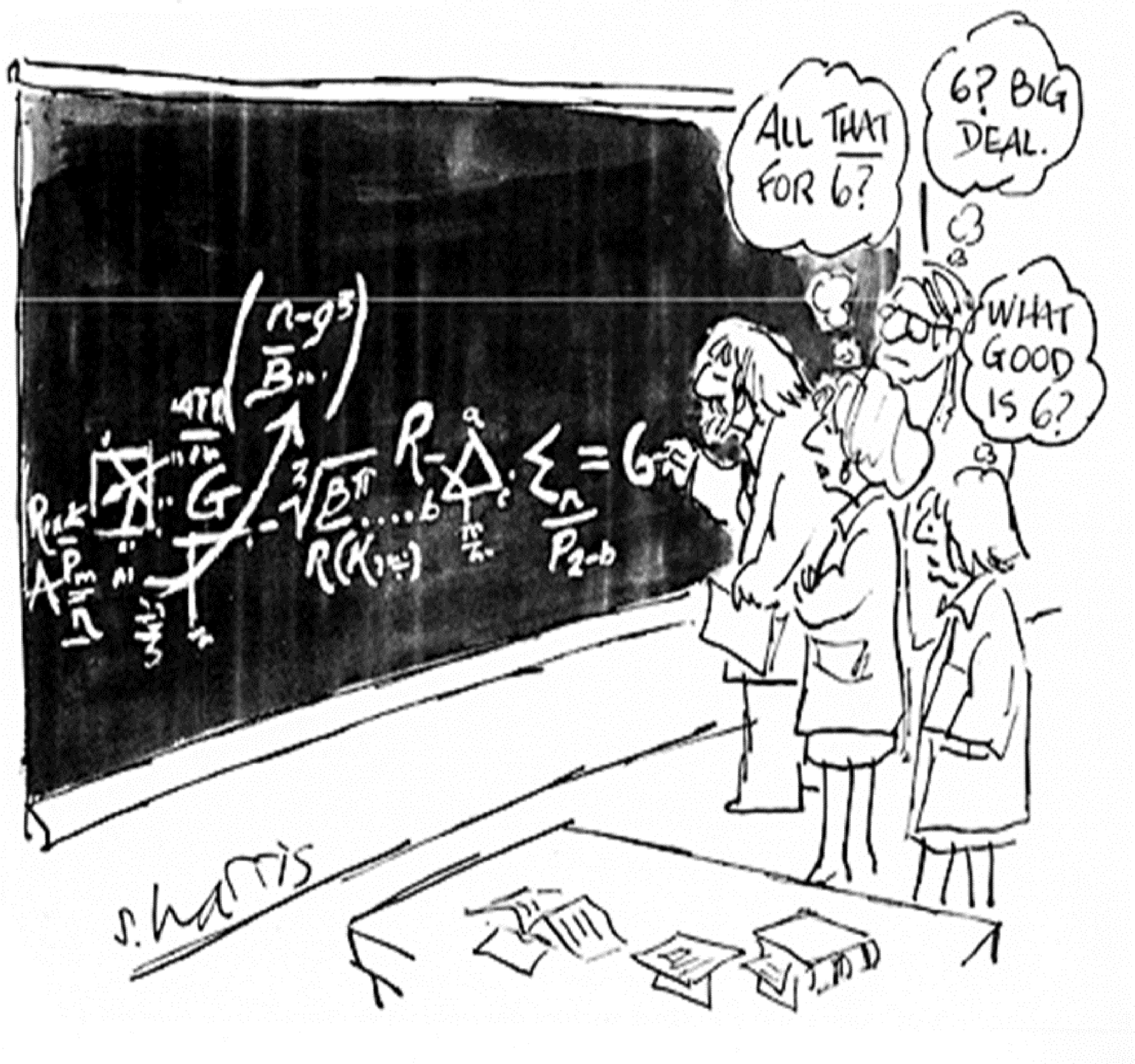
Calculate NPV for all project alternatives

$$NPV = \sum_{t=0}^{t} \frac{(B_t - C_t)}{(1+r)^t}$$

Where

- B = benefit (or cash inflow)
- C = cost (or cash outflow)
- B-C = net benefit (or net cash flow)
- t = time in years

Interpreting the Results of NPV



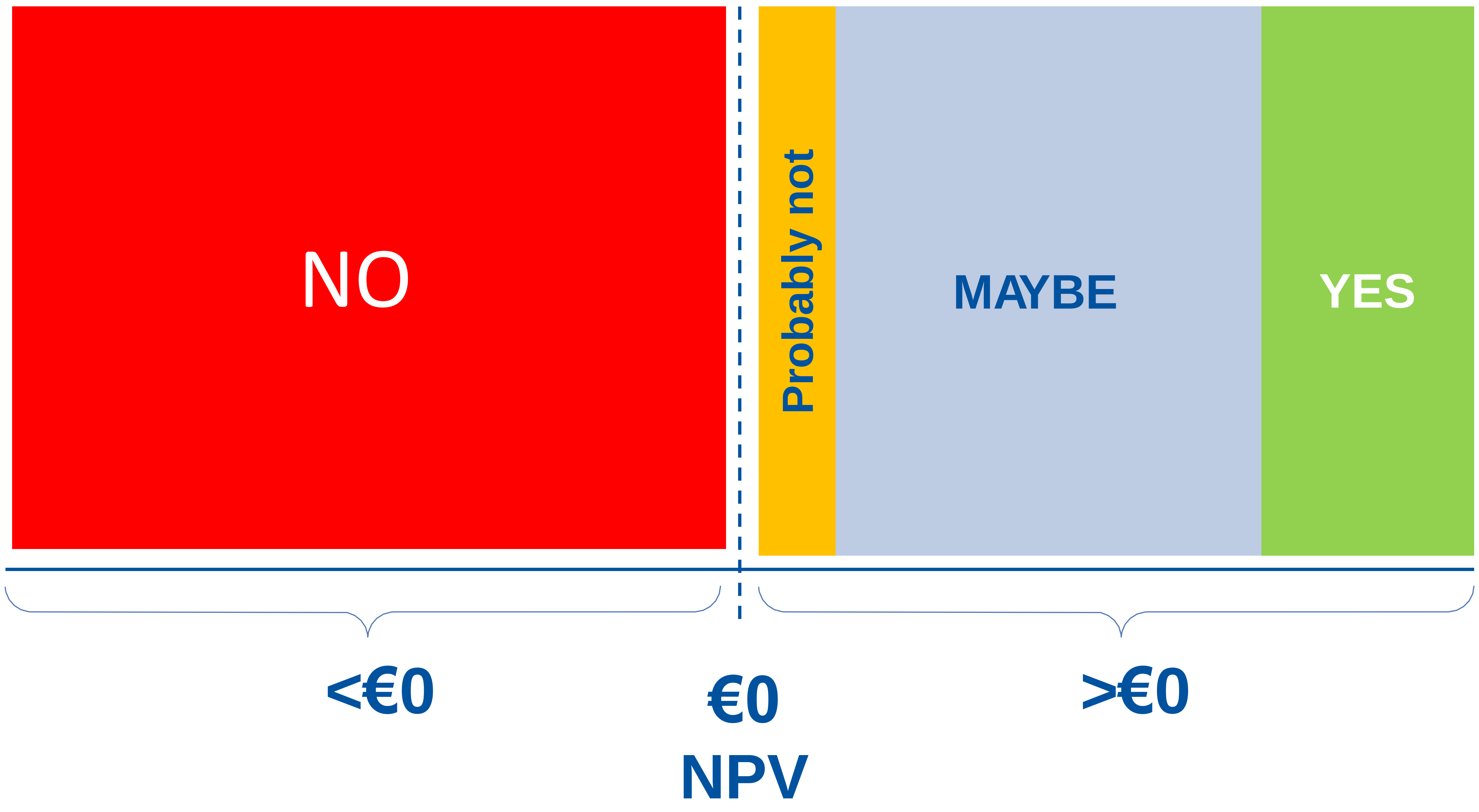
~~NPV < 0 reject~~

~~NPV = 0 indifferent~~

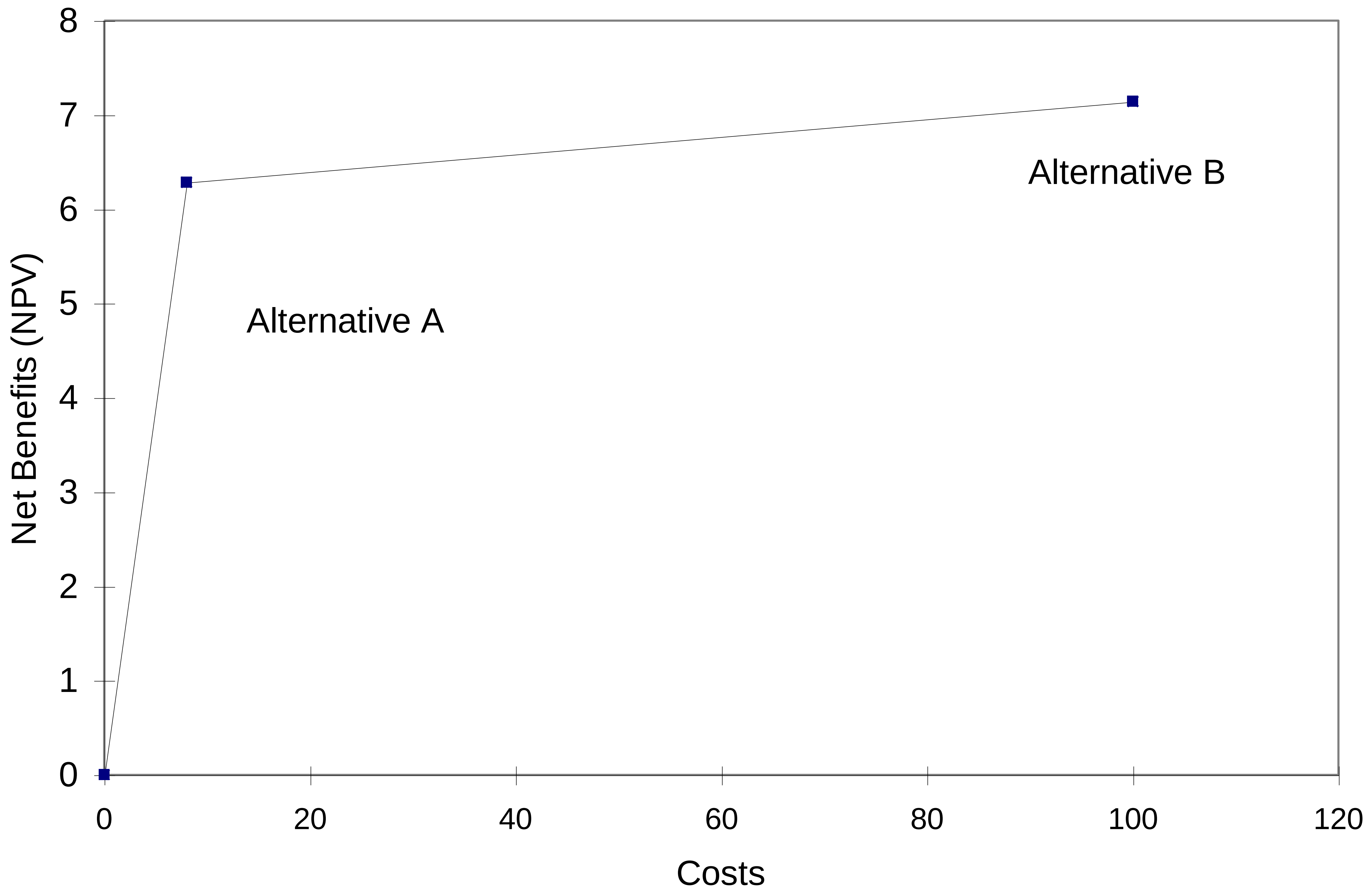
~~NPV > 0 accept~~

Interpreting the Results of a CBA

When is an NPV high enough?



Interpreting the Results of a CBA

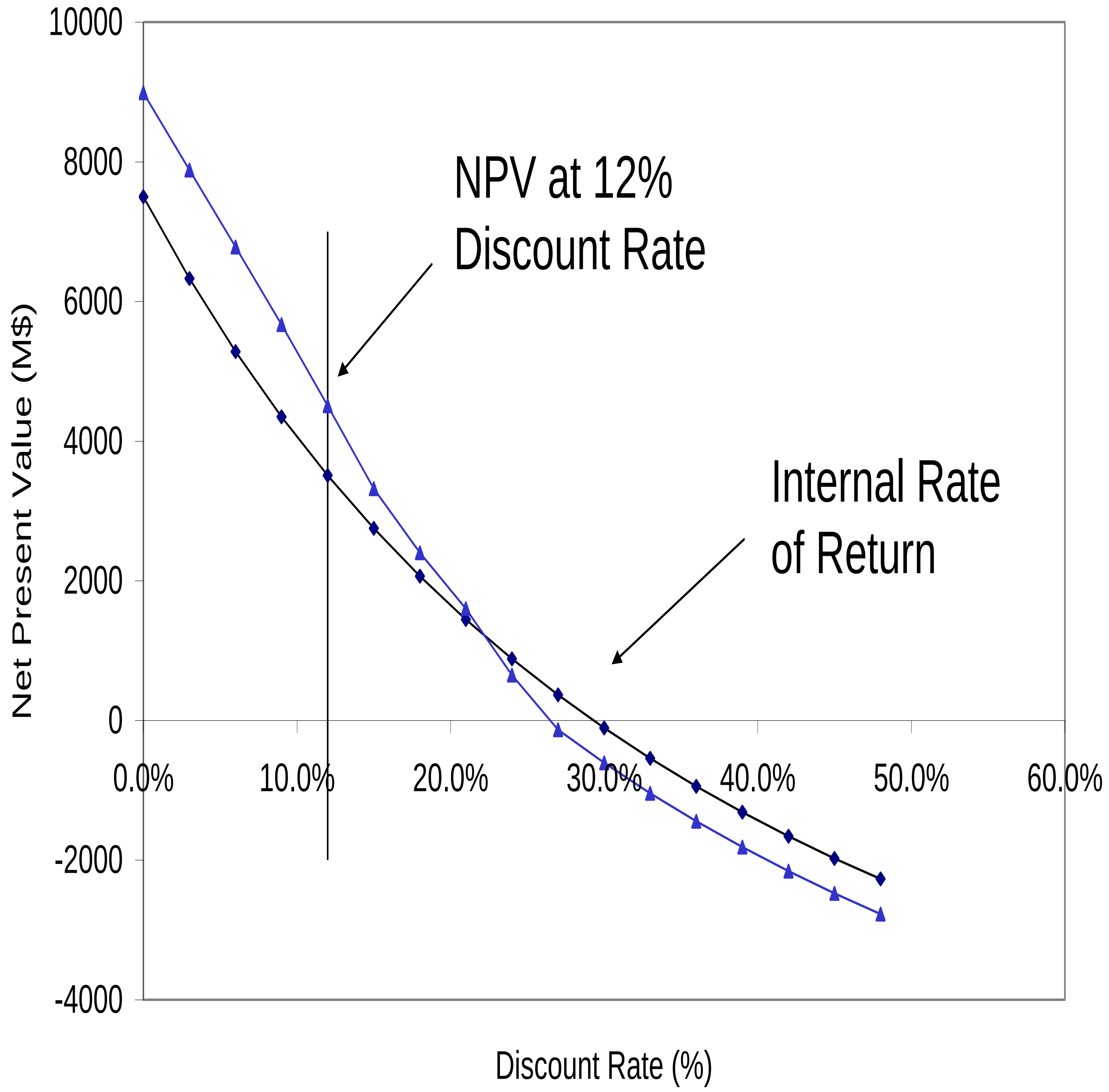


Complementary Measures of Economic Viability

Economic Internal Rate of Return (EIRR)

- The discount rate that would give an NPV of zero given the cash flow forecasts for the project
- It has some problems
  - Multiple IRRs / No IRR
  - Small investment bias
  - Assumes returns are reinvested at the same rate of return (not always the case)

NPV vs EIRR



The IRR and NPV will not necessarily rank the alternatives by the same order

Always use <u>NPV to compare project alternatives</u>

Complementary Measures of Economic Viability

1. NPV
2. EIRR
3. Benefit Cost Ratio (BCR)

$$BCR = \frac{sum\ of\ present\ values\ of\ benefits\ (cash\ inflows)}{sum\ of\ present\ values\ of\ costs\ (cash\ outflows)}$$

Let’s Practice!!!

Perform an Economic Analysis

Assumptions	
VAT	19%
Increase in Sales	10% / year
Initial Investment	
Land	7000
Infrastructure	15000
Equipment	4000
Start - up costs	1500
Road network	2500
Operating Expenses	
Raw materials	2250
Labor	750
Electric Power	300
Maintenance	450
Administrative Costs	80
Sales expenditure	170
Negative Externalities	2000
Benefits	
Sales	13600
Time Savings	5000
Positive Externalities	1500

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1 Define the project objectives and scope

Analyse risks and plan for their management

Construction risk

Demand risk

Design risk

Economic risk

Environmental risk

Funding risk

Legislative risk

Operation & maintenance risk

Procurement risk

Technological risk

How do we quantify risk?

How do we quantify risk?

1. Switching Values analysis
    - A switching value (percentage) for an input variable, such as capital cost, is that value at which the project's NPV turns zero
    - Easily calculated using a spreadsheet
    - Helpful in conceptualising the robustness of the economic case
- Equation
- $x = \frac{Value\ where\ NPV equals\ 0}{Original\ Value} - 100\%$

How do we quantify risk?

2. Sensitivity Analysis

- establishing the extent to which the results of the quantified economic analysis (NPV) are sensitive to changes in the values of the key input parameters
  - Deterministic Sensitivity Analysis
  - Probabilistic Sensitivity Analysis

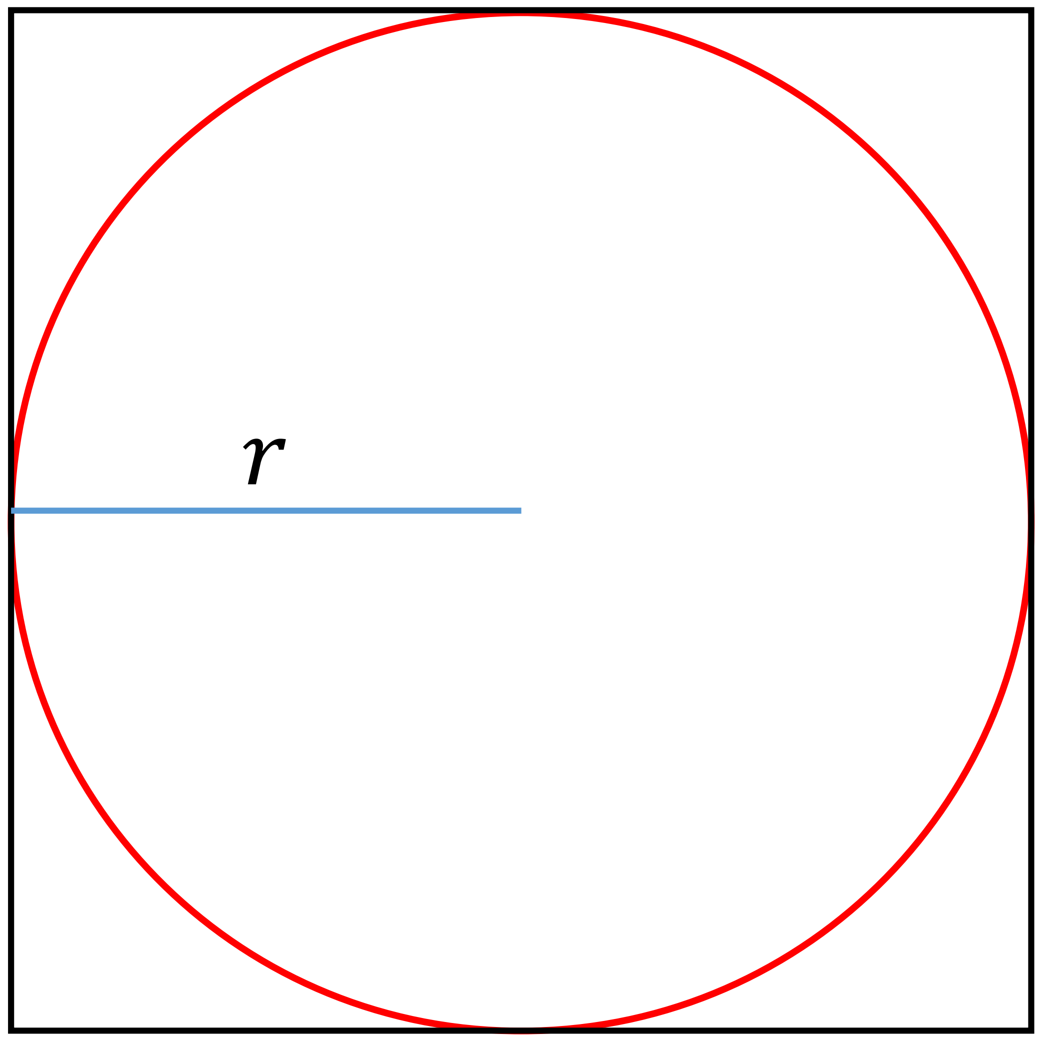
Deterministic Sensitivity Analysis

1. Recalculate NPV assuming a 10% increase in total costs
2. Recalculate NPV assuming a 25% increase in total costs
3. Recalculate NPV assuming a 10% decrease in total benefits
4. Recalculate NPV assuming a 25% decrease in total benefits
5. Recalculate NPV assuming a simultaneous increase in costs of 10% and decrease in benefits of 10% - the basic pessimistic scenario
6. Recalculate NPV assuming a <u>simultaneous increase in costs of 25%</u> and <u>decrease in benefits of 25%</u> - the basic worst-case scenario

Probabilistic Sensitivity Analysis

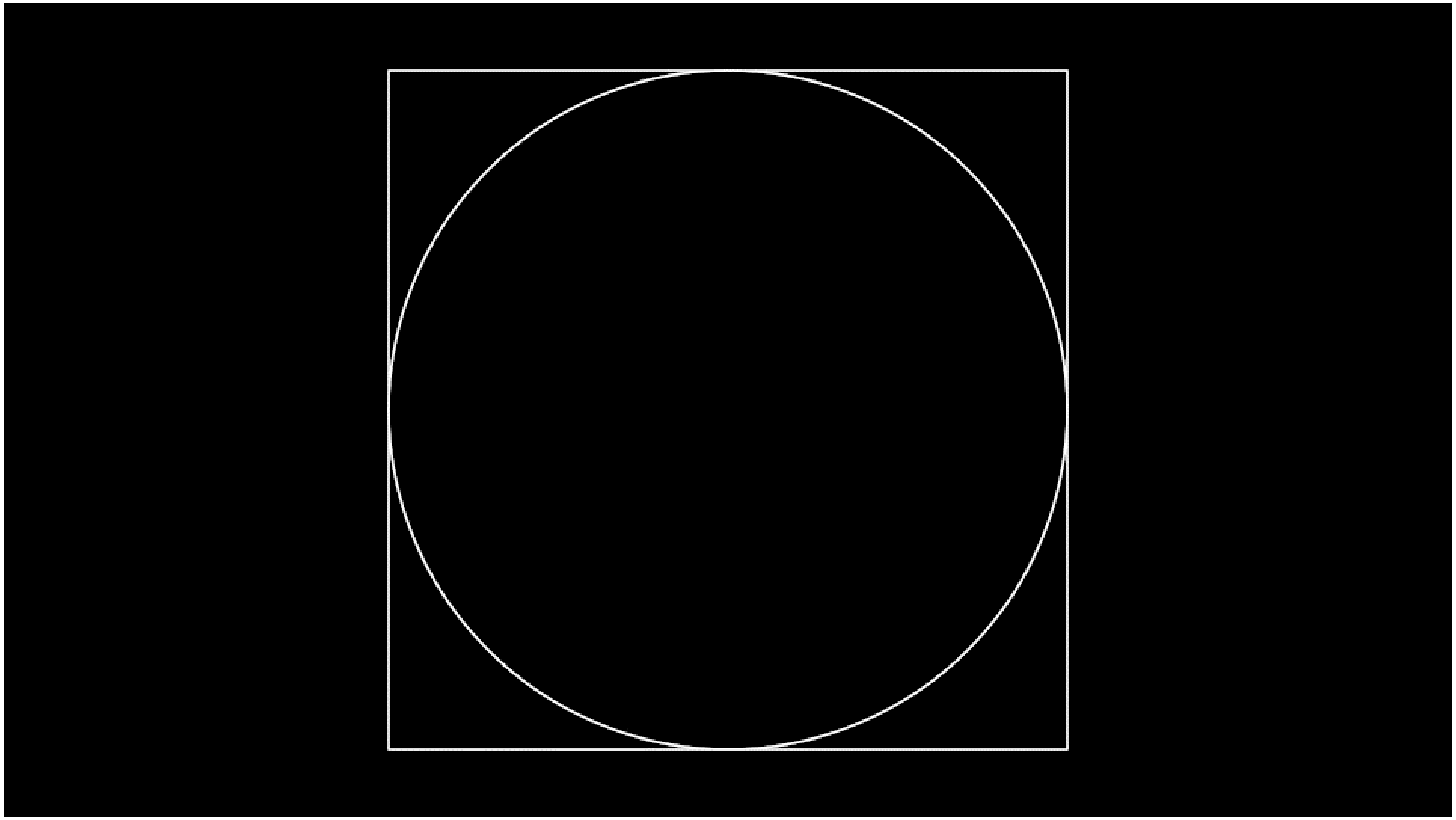
- Monte Carlo Analysis
- More sophisticated technique
- Generally, it will only be required for very large and complicated projects
- Probability Distributions
- Expected Values (Expected NPV)

Monte Carlo

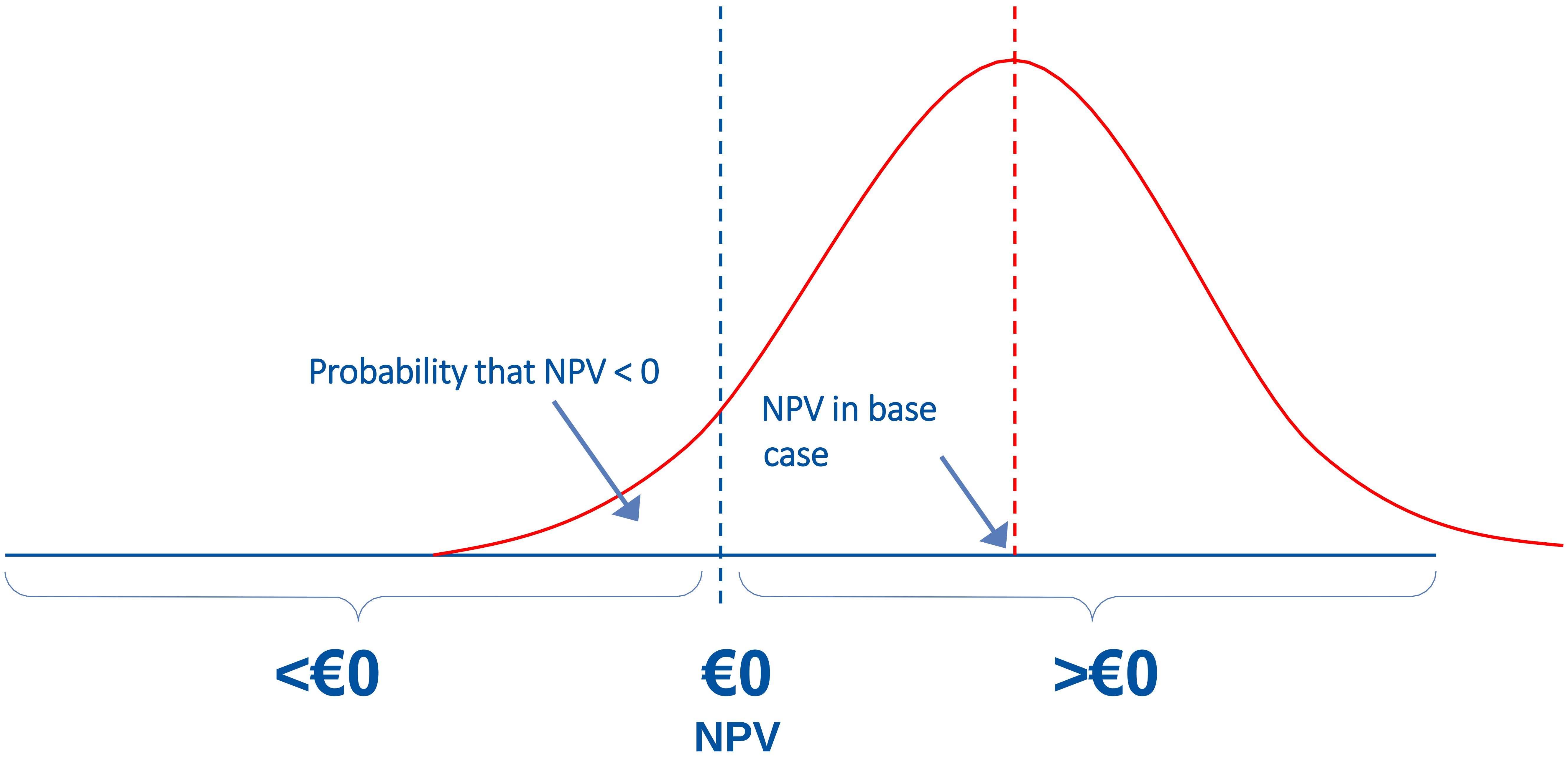


$$P = \frac{Area\ of\ Circle}{Area\ of\ Square} = \frac{\pi r^2}{(2r)^2} = \frac{\pi r^2}{4r^2} = \frac{\pi}{4} = 0.785398$$

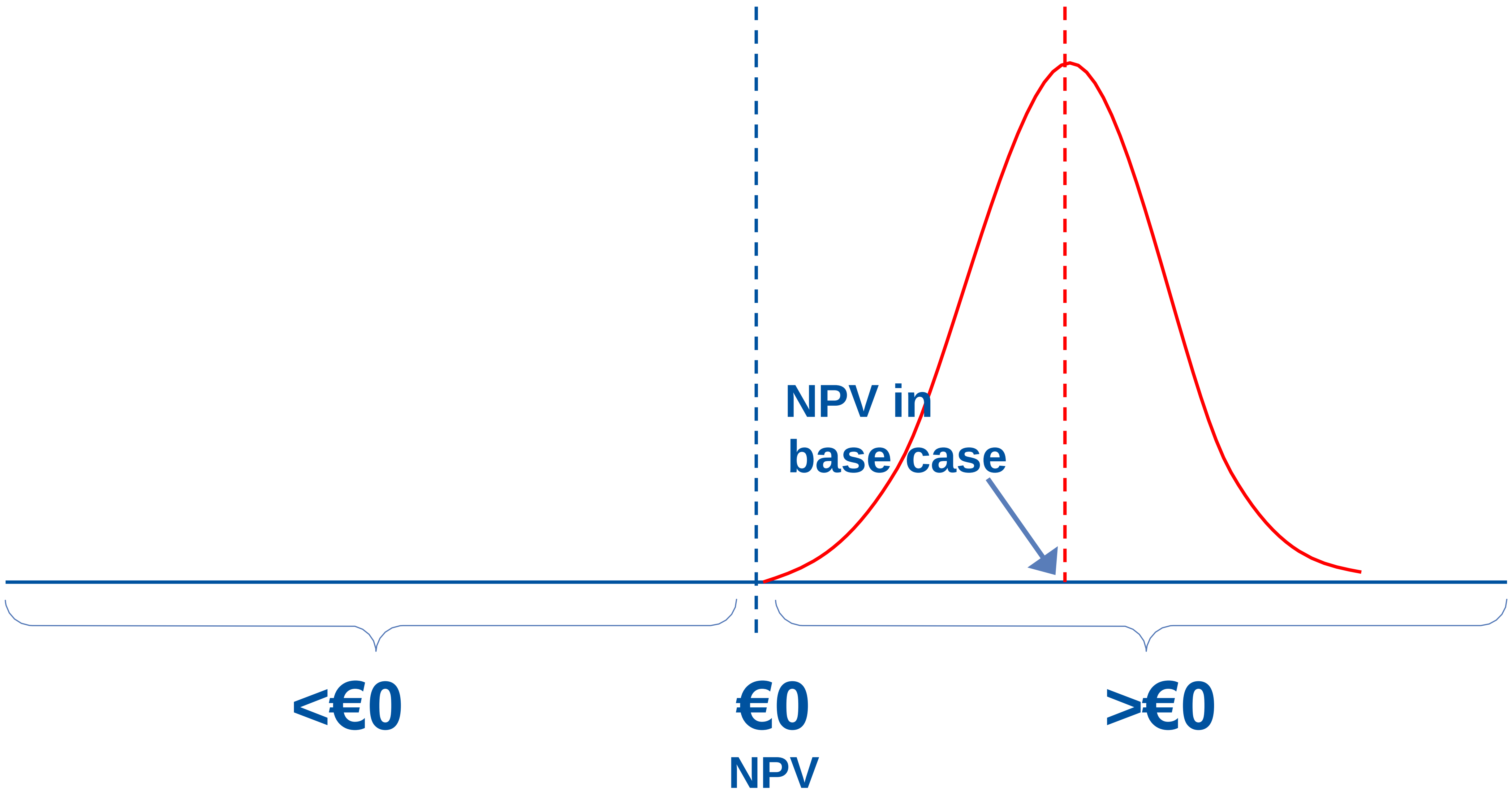
$$P = \frac{Area\ of\ Circle}{Area\ of\ Square} = \frac{\pi r^2}{(2r)^2} = \frac{\pi r^2}{4r^2} = \frac{\pi}{4} = 0.785398$$



Analyse risks



Analyse risks



Analyse risks and plan for their management

Management of Risks

Present a plan for managing key risks, including mitigation measures and/or reactive measures should the risks occur

Management of Risks

All financially significant projects are expected to have a risk management plan

Risk Matrix

RISK RATING KEY	LOW	MEDIUM	HIGH	EXTREME
	0 – ACCEPTABLE	1 – ALARM (as low as reasonably practicable)	2 – GENERALLY UNACCEPTABLE	3 – INTOLERABLE
	OK TO PROCEED	TAKE MITIGATION EFFORTS	SEEK SUPPORT	PLACE EVENT ON HOLD

		SEVERITY			
		ACCEPTABLE LITTLE TO NO EFFECT ON EVENT	TOLERABLE EFFECTS ARE FELT, BUT NOT CRITICAL TO OUTCOME	UNDESIRABLE SERIOUS IMPACT TO THE COURSE OF ACTION AND OUTCOME	INTOLERABLE COULD RESULT IN DISASTER
LIKELIHOOD	IMPROBABLE RISK IS UNLIKELY TO OCCUR	LOW	MEDIUM	MEDIUM	HIGH
	POSSIBLE RISK WILL LIKELY OCCUR	LOW	MEDIUM	HIGH	EXTREME
	PROBABLE RISK WILL OCCUR	MEDIUM	HIGH	HIGH	EXTREME

Let’s Practice!!!

Steps in Project Appraisal

9 Identify the preferred project alternative - Recommendation

8 Assess affordability and sustainability

7 Analyse risks and plan for their management

6 Calculate NPV for all project alternatives

5 Value economic benefits and costs

4 Identify relevant benefits and costs

3 Demonstrate the demand for the services

2 Identify and choose project alternatives

1 Define the project objectives and scope

Financial vs Economic Analysis

Major Differences between Financial and Economic Cost-Benefit Analysis

	Financial Analysis	Economic Analysis
Perspective	Agency/organisation/firm	Economy/society
Objective	Analysis of the net financial impact of the proposal on the agency	Maximising the social returns to the economy's resources
Pricing	Market prices	Opportunity costs/shadow prices
Transfer payments (taxes & subsidies)	Included	Excluded
Equity/distributional effects	Excluded	Can be included, usually treated qualitatively
Externalities	Excluded	Included
Depreciation	Excluded (from discounted cash flow analysis, but included in financial statements).	Excluded

Financial Analysis

Financial analysis of a public capital investment project is carried out for several reasons:

- To verify that a revenue earning project is financially sustainable and will have sufficient funds to meet its commitments at each stage of its life.
- In the case where a project is not financially sustainable, to identify any changes to tariff regimes or provision of budget subsidies that may be necessary.
- For commercially-oriented public operating entities, to ascertain whether an investment is profitable and thus contributes to improving overall profitability (or reducing losses in the case of entities subsidised from the national budget).
- In the case where a project is potentially profitable, to point towards possible financing modalities, including public-private partnership.

Financial Analysis

Financial analysis is applicable to revenue earning projects,

- for example, investment by public sector energy and water utilities or by public transport operators.
- For non-revenue earning projects, for example in the health, education, justice and roads sectors, a meaningful financial analysis may not be feasible and therefore may not be required .

Assess affordability and sustainability

1. Carry out financial analysis of the project to determine financial sustainability and profitability
   - Financial sustainability = project's revenues cover its costs (it will not run out of cash)
   - Financial sustainability ≠ financial profitability
   - FIRR > WACC (Weighted Average Cost of Capital)

- Financial analysis is applicable to revenue earning projects, for example, investment by public sector energy and water utilities or by public transport operators. For non-revenue earning projects, for example in the health, education, justice and roads sectors, a meaningful financial analysis may not be feasible and therefore may not be required.

Assess affordability and sustainability

1. Carry out financial analysis of the project to determine financial sustainability and profitability
2. Carry out Budgetary Analysis as an Input to Assessing Affordability
   - Net impact on the national budget
   - Current prices

Budget Impact Analysis

	Year 1	Year 2	Year…	Year 7	Post-Year 7
Budgetary Costs Capital Costs Net Recurrent Costs • Operations • Maintenance					
Total Costs					
Projected budgetary revenues (if any)					
Net Budgetary Impact					

Assess affordability and sustainability

1. Carry out financial analysis of the project to determine financial sustainability and profitability
2. Carry out Budgetary Analysis as an Input to Assessing Affordability
3. Assess institutional/managerial sustainability of the project
    - assessment of the capacities of the organisation(s) responsible for implementing and operating the project
    - key milestones (planning, approval, construction)

Assess affordability and sustainability

1. Carry out financial analysis of the project to determine financial sustainability and profitability
2. Carry out Budgetary Analysis as an Input to Assessing Affordability
3. Assess institutional/managerial sustainability of the project
4. Assess environmental and social sustainability of the project
   - Monetised (already assessed in Steps 4 – 5)
   - Non-monetised costs and benefits should at least be identified in quantitative or qualitative terms and their relative importance compared to monetized benefits and costs assessed

Let’s Practice!!!

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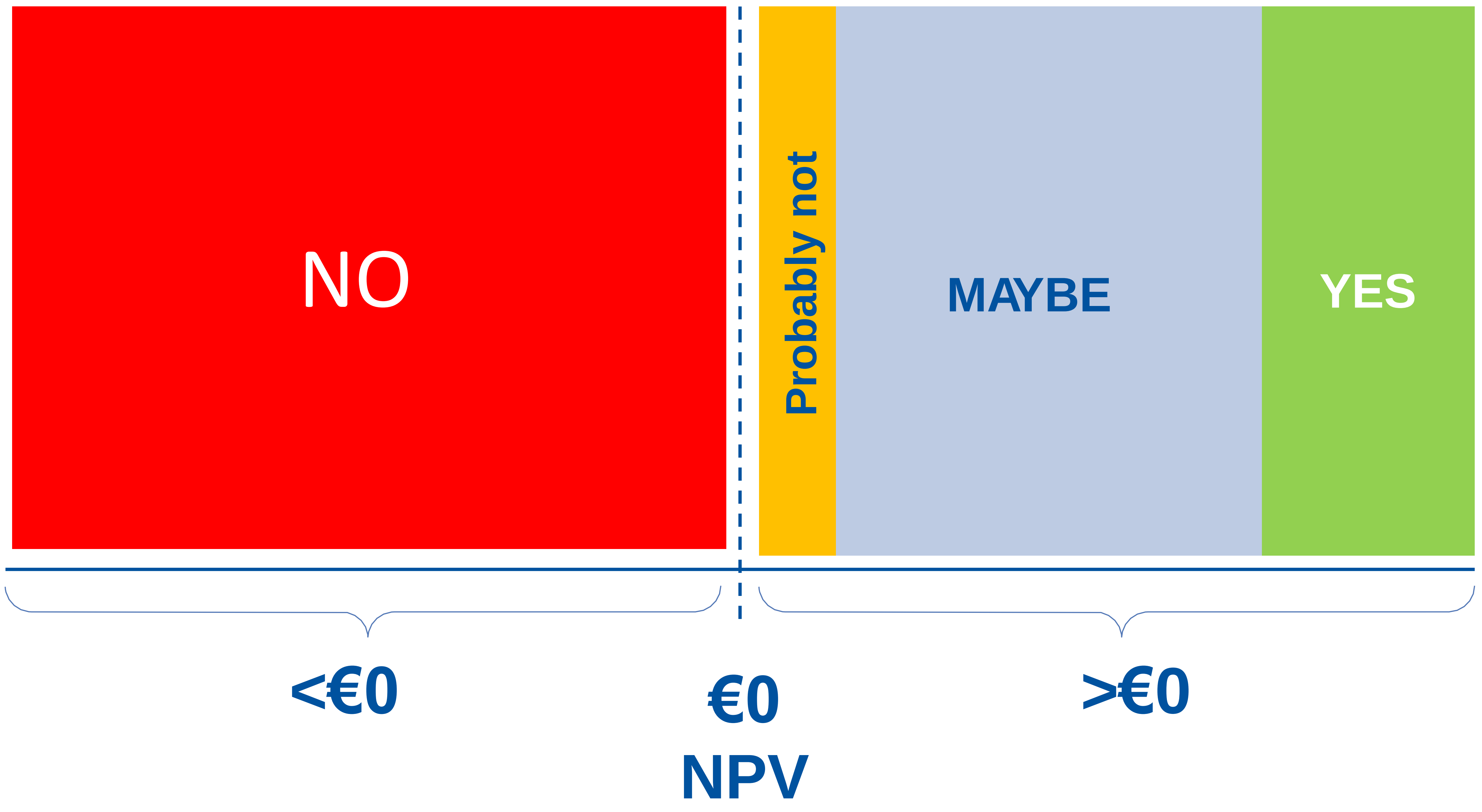
1 Define the project objectives and scope

Identify the preferred project alternative

Make a Recommendation

Interpreting the Results of a CBA

When is an NPV high enough?



Multicriteria Analysis

Take into Account Non-Monetised Benefits and Costs and Affordability and Sustainability

Multicriteria Analysis

1. Identifying (generally non-monetised) project effects that are judged important enough to be decision criteria.

Multicriteria Analysis

Multicriteria Analysis

1. Identifying (generally non-monetised) project effects that are judged important enough to be decision criteria.
2. Scoring project alternatives against these criteria - using quantitative measures of effects upon which to base scores wherever possible.

Multicriteria Analysis

	g1	g2	g3	g4

Multicriteria Analysis

1. Identifying (generally non-monetised) project effects that are judged important enough to be decision criteria.
2. Scoring project alternatives against these criteria - using quantitative measures of effects upon which to base scores wherever possible.
3. Determining weights reflecting the relative importance of the criteria

Multicriteria Analysis

	g1	g2	g3	g4
x1	0.56	0.51	0.1	0.34
x2	0.93	0.74	0.45	0.22
x3	0.71	0.69	0.21	0.41
x4	0.99	0.44	0.99	0.57

	g1	g2	g3	g4
Weights	4	2	1	1

Multicriteria Analysis

1. Identifying (generally non-monetised) project effects that are judged important enough to be decision criteria.
2. Scoring project alternatives against these criteria - using quantitative measures of effects upon which to base scores wherever possible.
3. Determining weights reflecting the relative importance of the criteria
4. Combining the weights and scores for each of the alternatives to derive an overall value

Multicriteria Analysis

	x1	x2	x3	x4
Overall	3.70	5.87	4.84	6.40

Multicriteria Analysis

1. Identifying (generally non-monetised) project effects that are judged important enough to be decision criteria.
2. Scoring project alternatives against these criteria - using quantitative measures of effects upon which to base scores wherever possible.
3. Determining weights reflecting the relative importance of the criteria
4. Combining the weights and scores for each of the alternatives to derive an overall value - multiplying the value score on each criteria by the weight of that criterion, and then adding all the weighted scores together.
5. Performing a sensitivity analysis to test the sensitivity of the results to changes in the scores and weights.

Multicriteria Analysis

	g1	g2	g3	g4
x1	0.56	0.51	0.1	0.34
x2	0.93	0.74	0.45	0.22
x3	0.71	0.69	0.21	0.41
x4	0.99	0.44	0.99	0.57

	g1	g2	g3	g4
Weights	4	2	1	1

Let’s Practice!!!

Steps in Project Appraisal

9. Identify the preferred project alternative - Recommendation
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4. Identify relevant benefits and costs
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2. Identify and choose project alternatives
1. Define the project objectives and scope

Cost Effectiveness Analysis

Major Difference

It does not involve placing money values on the major benefits of a project

Cost Effectiveness Analysis

Cost-effectiveness analysis compares the cost of alternative ways of producing the same or very similar outputs or outcomes

Cost Effectiveness Analysis

Result

Net Present Cost (NPC)

NPC/Unit Output (Outcome)

Let’s Practice!!!

Deliverables

- Feasibility Study
  - supported by technical studies and impact assessments
  - template for the outline of feasibility study is presented as Annex 5 to the Manual
- Project Appraisal Report
  - executive summary of the feasibility study
  - must contain a clear recommendation on whether to proceed, justified on the basis of the feasibility study findings
  - A template for a Project Appraisal Report is presented as Annex 6 to the Manual

Deliverables – DG EPCD Advice

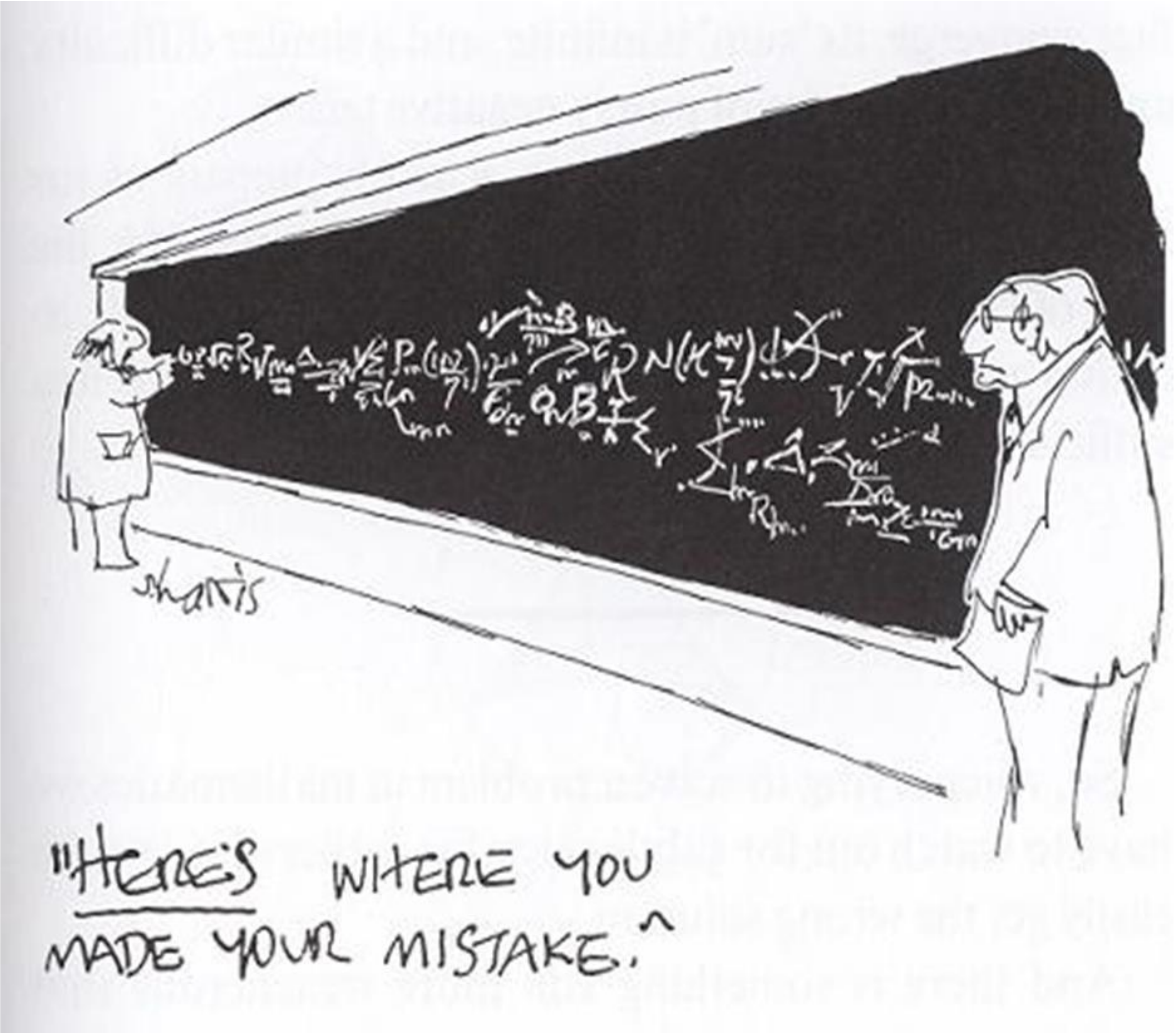
Deliverables

Raw data and worksheets (excel files etc) used to calculate the various parameters of the Feasibility Study, must be submitted in electronic form, in order to enable the review of assumptions and calculations by the DG EPCD

Reproducibility (Replicability)

The ability of a researcher to duplicate the results of a prior study using the same materials as were used by the original investigator

Review Process



Checklist !!!!

Annex 4
Checklist

Manual for Pre-Selection and Appraisal of Public Investment Projects

Government of Cyprus

What not to do?

1. Feasibility Study not based on our manual
2. “Hidden” Assumptions
3. “Disclaimer”
4. WOP scenario compared to single WP alternative

What not to do?

5. Valuation of benefits is largely based on <u>indirect</u> benefits
    - Avoid “GDP-increase” methods (Avoid double counting)
6. CBA does not contain information on potentially significant <u>non-quantified</u> costs or benefits
7. Risk analysis in CBA is <u>not based</u> on realistic scenarios
8. Risk analysis does not discuss <u>measures to reduce risks</u>
9. CBA assumes that project will generate similar benefits as previous project (benefit transfer)

www.dgepcd.gov.cy

EN - English

ΚΥΠΡΙΑΚΗ ΔΗΜΟΚΡΑΤΙΑ

Γενική Διεύθυνση Ευρωπαϊκών Προγραμμάτων, Συντονισμού και Ανάπτυξης

Ευρωπαϊκά Ταμεία και Προγράμματα | Συντονισμός Κυβερνητικού Έργου | Ανάπτυξη

- Αρχική Σελίδα
- Φιλική Εκτύπωση
- Κυβερνητική Πύλη
- Συνήθεις Ερωτήσεις

Αναζήτηση... GO

- ⊞ ΓΔ ΕΠΣΑ
- ⊞ Ευρωπαϊκά Διαρθρωτικά και Επενδυτι... Ταμεία
- Ευρωπαϊ... ...ταγωνιστικά Προγράμ...
- Πολυετή... ...οτικός Προϋπολ... ...ός
- Χορηγίες ... και Νορβηγίας
- Χορηγίες ... ...τίας
- Ταμείο Ε... ...ηματικότητας Κύπρου
- Συντονισ... Κυβερνητικού Έργου
- ⊞ Εφαρμογ... ...ημονίου
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- ⊟ Αξιολόγηση Δημοσίων Επενδυτικών Έργων
  - Νόμος
  - Οδηγίες
  - Εγχειρίδιο
  - Σημείωμα Έργου
  - Έκθεση Αξιολόγησης Έργου
  - Συμπράξεις Δημόσιου και Ιδιωτικού Τομέα (ΣΔΙΤ)
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Ημερολόγιο Εκδηλώσεων

Μάιος 2018 Go

Δ	Τ	Τ	Π	Π	Σ	Κ
	01	02	03	04	05	06
07	08	09	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

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Instead of an Epilogue

"It is best to think of the cost-benefit approach as a way of organizing thought rather than as a substitute for it."

Michael Drummond

Appendix

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The Channel Tunnel—an ex post economic evaluation

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Abstract

The forecasts underpinning the construction of the Channel Tunnel largely and systematically overestimated the total size and growth of the cross-Channel passenger and freight markets. The share of the cross-Channel markets captured by the Tunnel was accurately predicted. However, this was only achieved through a competitive battle with ferry operators, which resulted in reduced tariffs. The combination of these two factors resulted in revenues much lower than predicted. For completely separate reasons, the construction costs of the Tunnel doubled.

The cost benefit appraisal of the Channel Tunnel reveals that overall the British economy would have been better off had the Tunnel never been constructed, as the total resource cost outweighs the benefits generated. Users have gained significantly at the expense of owners (producers). The latter—both ferry operators and the Tunnel operator have incurred substantial losses. The single biggest component of user's gain has not, as originally expected, been in terms of travel time savings, but due to the transfer from producers. The longer-term evaluation of the project confirms the poor viability of the investment both in financial and cost benefit terms.

Eurotunnel has in recent months been the focus of much media attention. In the Extraordinary General Meeting (EGM) of April 2004 the shareholders voted to replace the management with a new French-dominated Executive. Project DARE was launched in October 2004, with the aim to address the company's difficult situation. The developments over the next few months will be critical for Eurotunnel, given the approaching end of the Minimum Usage Charge (MUC) period in November 2006 and the start of the repayment of junior debt from 2007.

Keywords: Channel Tunnel; Forecasts; Appraisal

1. Scope

This paper describes the Channel Tunnel's (CT) turbulent past, from the problems encountered in the late 1950s, when the project was first seriously examined, through to today's traffic levels and financial viability issues. It highlights the troubles with the initial project proposals and compares the actual traffic levels with the historical forecasts. The financial and cost benefit appraisals draw on the analysis and comparison of costs and revenues and on the detailed welfare analysis.

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The historical sets of forecasts undertaken historically prior to and during the construction of the tunnel are presented. Moreover, this paper identifies the scale and effects of the large deviations in the forecasting exercises. It does not, however, deal with any potential methodological, original database, or other issues which may have affected the historical forecasts.

In terms of construction costs, it identifies the scale, sources and effects of the errors (with regards to project appraisal). It does not attribute or identify causes on the methodological, social or political aspects of the process.

The paper shows that the large debt accumulated by Eurotunnel is a consequence from the transfer from owners (or producers) to users. The current issues (shareholders revolt, changes of management and other legal battles) are actually about which producers—original shareholders, banks or even British and French taxpayers, should bear the debt burden.

2. Historical developments 1957–1986

The idea of a tunnel under the English Channel has been discussed for over 200 years. The first feasible plan is thought to have been devised by Albert Mathieu in 1802. He envisaged twin bored tunnels between Cap Gris Nez (near Calais) and Eastwell Bay (near Folkestone), remarkably similar to the present tunnel in terms of both design and location. The first attempt to construct a Channel Tunnel was by Colonel Beaumont in 1880, which the British Government—led by His Royal Highness George, Duke of Cambridge—halted to "avoid a new element of danger that would threaten our very national existence".[1] These national security issues and the lack of adequate engineering techniques prevented the project from being taken forward for nearly a further 100 years (Slater and Barnett, 1957).[2]

Within a context of immense growth in traffic between the UK and the Continent after the Second World War, and, more importantly, with the recognition that traffic would continue to grow in subsequent years, successive administrations during the 1960s agreed that the Channel Tunnel project was feasible and that the means to actually carrying it out should be fully examined.

Serious modern consideration of the construction of the CT commenced in 1957 when an Anglo-French Channel Tunnel Study Group was established. In 1960, an alternative Channel Bridge Study Group was set up in Paris. These submitted respective proposals in March 1960 and October 1961 for fixed links across the Channel. In November 1961 the Governments set up a joint official *Working Group of French and British Officials* to examine the proposals.

In July 1963 this working group reported in favour of a Channel Tunnel (MoT, 1963), and in July 1966, the French and British Prime Ministers announced the joint decision that subject to finding a solution for the construction work on mutually acceptable terms, the Tunnel should be built. However, none of the proposals received were considered acceptable. A new combined group presented revised proposals in 1970 and in March 1971 the British and French Ministers accepted the new scheme.

Arrangements for the financing and construction proceeded slowly. Following the publication of The Channel Tunnel White Paper (DoE, 1973), it was expected that a hybrid Bill would enable the Anglo-French treaty to be ratified by 1 January 1975.

However, the in-coming Labour Government decided to reassess the project and a Channel Tunnel Advisory Group (CTAG) was set up under Sir Alec Cairncross to report by Spring 1975. This implied that the Anglo-French Treaty could not be ratified by the agreed date of 1 January 1975. On 20 January 1975 the British Government conceded that the project had been abandoned; the UK had unilaterally withdrawn.

The project re-emerged in 1979 and in March 1980 the Government announced that it looked forward to receiving proposals for a tunnel or other fixed link across the Channel. A so-called UK-French Study Group published its report "Fixed Channel Link" in June 1982 (DoT, 1982) giving cautious support to the Tunnel alternative ahead of bridge, submerged tubes and hybrid proposals.

1 The British Army's Field Marshal Commander in Chief (His Royal Highness George, Duke of Cambridge) in a memorandum to the Secretary of State for War in Gladstone's Cabinet of 1882, as reported by Slater and Barnett (1957).

2 For a comprehensive account of the history of the Channel Tunnel from its very origins up until 1957, see Slater and Barnett (1957).

Despite the early appraisals suggesting significant financial returns, the capital markets were not prepared to back any of the proposed schemes.

Finally, in April 1985 the French and UK Governments issued an invitation to promoters seeking proposals for the development, financing, construction and operation of a fixed link across the Channel between England and France. The two Governments ruled out any support from public funds or any financial guarantees and required that the proposals should be for fixed links to be constructed and operated entirely at the promoters' own risk.

After examination or the four proposals received,[3] on 20 January 1986, the Prime Minister of the UK and the President of France issued a joint statement announcing the decision of the two Governments to facilitate the construction of a fixed link across the Channel by the Channel Tunnel Group-France Manche (CTG-FM) consortium.

3. Traffic forecasts

A large number of studies were undertaken in the 25 years leading to the construction of the Tunnel. A fundamental part of all the studies were the traffic forecasts.

Tables 1 and 2 show the historical forecasts of Channel Tunnel traffic and total cross-Channel market for passenger and freight traffic respectively.

The CTG-FM's proposal and subsequent updates provided by Eurotunnel[4] also included a prediction of the total demand for cross Channel traffic and a subsequent estimation of the likely passenger and freight diversion to the tunnel link.

Table 1
Total cross-channel passenger and channel tunnel passenger historical forecasts (millions of passengers)

		1969	1971	1980	1985	1990	2000
MoT (1963)	Total demand	5.37	5.52	6.22	5.78	–	–
	Via tunnel	4.71	4.83	5.38	5.66	–	–
C&L (1973)	Total demand	–	24.95	46.76	–	93.27	–
	Via tunnel	–	–	15.85	–	29.52	–
CTAG (1975)	Total demand	–	24.93	42.32	–	72.01	–
	Via tunnel	–		14.59	–	24.18	–
DoT (1982)	Total demand	–	–	20.6	–	35.7	48.4
	Via tunnel	–	–	–	–	15.3	19.8

Sources: MoT (1963), C&L (1973), CTAG (1975) and DoT (1982).

Table 2
Total cross-channel freight and channel tunnel freight historical forecasts (millions of tonnes)

		1969	1971	1980	1985	1990	2000
MoT (1963)	Via tunnel	2.6	2.9	4.0	4.5	–	–
C&L (1973)	Total demand	–	5.7	13.1	–	25.3	–
	Via tunnel	–	–	5.4	–	11.3	–
CTAG (1975)	Total demand	–	5.7	12.9	–	20.2	–
	Via tunnel	–	–	5.3	–	7.8	–
DoT (1982)	Total demand	–	–	15.9	–	27.3	37.2
	Via tunnel	–	–	–	–	8.6	11.1

Sources: MoT (1963), C&L (1973), CTAG (1975) and DoT (1982).

[3] "Channel Expressway" (Separate road and rail tunnels), "Eurobridge" (Independent road and rail bridges), "Euroroute" (Combined road and rail tunnel-bridge-tunnel) and the "Channel Tunnel" (rail tunnels).

[4] Offer for Sale (ET, 1987), first Rights Issue (ET, 1990) and second Rights Issue (ET, 1994).

As shown in Table 3, the promoters of the Tunnel were aiming to capture two thirds of the car-accompanied market within the first year of operation.

The traffic forecasts for both the passenger and freight total markets were revised significantly upwards, the main change being the increase in the total transport market. The size of the cross Channel passenger market for 2003 was estimated to be 34% higher in the 1990 forecasts than it was in 1987 (Table 4).

The combined effect of the changes in the total market and assumed diversion rates was, both for the passenger and freight markets, a considerable increase in the absolute projected traffic through the Tunnel. Flyvbjerg et al. (2003) explain this "by the need to preserve the confidence of the shareholders and of the banks when new cost overruns became apparent in the project"[5].

The 1994 forecasts appear to have taken into account the slower than predicted market growth, but are still higher than the 1985 estimate (Table 5).

Table 3
CTG-FM passenger and unitised freight forecasts—total demand (1993) and tunnel share (1993 and 2003) (millions of passengers and millions of tonnes)

	1993			2003
	Total demand	Tunnel		Tunnel passengers[a]
		Tunnel passengers	Market share (%)	
Car passengers	9.5	6.3	66	7.3
Coach passengers	8.4	4.4	52	5.5
Day trip passengers	3.2	3.1	97	3.4
Other foot passengers	46.1	10.9	24	12.9
Total passengers	67.2	24.7	37	29.1
		Tunnel freight	Market share (%)	Tunnel freight[a]
Roll on/roll off freight[b]	24.2	6.0	25	7.5
Containers and rail wagon	7.9	4.0	52	6.8
Total	32.1	10.0	31	14.3

[a] CTG-FM's assessment of the total demand for 2003 was not published. *Source*: CTG-FM (1985).
[b] Roll on/roll freight are accompanied lorries "rolling on and off" ferries or other vehicle shuttles.

Table 4
ET (1987, 1990) passenger and freight forecasts (million of trips/tonnes)

	1993		2003	
	Traffic volumes	Tunnel market share	Traffic volumes	Tunnel market share
1987 update				
Total passenger demand	67.1		93.6	
Channel Tunnel traffic	29.7	44%	39.5	42%
Total unitised freight market	42.4		62.6	
Channel Tunnel traffic	14.8	35%	21.1	34%
1990 update				
Total passenger demand	84.2		125.2	
Channel Tunnel traffic	28.6	34%	44.6	36%
Total unitised freight market	47.2		74.5	
Channel Tunnel traffic	16.2	35%	26.8	36%

Sources: ET (1987, 1990).

[5] Flyvbjerg et al. (2003) Megaprojects and risk: An anatomy of ambition, p. 23.

Table 5
ET (1994) passenger and freight forecasts (million of trips/tonnes)

	1994		1995		1996		2003	
	Traffic volumes	Tunnel market share	Traffic volumes	Tunnel market share	Traffic volumes	Tunnel market share	Traffic volumes	Tunnel market share
Total passenger demand	71.7		77.7		82.5		107.5	
CT traffic	2.9	4%	16.3	21%	21.8	26%	35.8	33%
Total unitised freight market	43.8		47.4		50.2		73.4	
CT traffic	2.6	6%	11.1	23%	16.0	32%	25.3	33%

Source: ET (1994).

4. Actual traffic volumes

4.1. Passengers

The numbers of passengers using the Channel Tunnel are presented in Table 6.

The comparison of the actual results and historical forecasts shows that the actual numbers of passengers have clearly fallen short of expectations. Eurotunnel's forecasts were extremely optimistic, forecasting between 2 and 3 times the current numbers of passengers (Fig. 1).

The large overestimation of the levels of passenger traffic through the Channel Tunnel may be driven either by an overestimation of the total cross-Channel market, by a miscalculation of the actual share of the market captured by the Tunnel, or by both.

Table 6
Actual Channel Tunnel passengers, 1994–2003 (millions of passengers)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Eurostar passengers	0.1	2.7	4.9	6.0	6.3	6.6	7.1	6.9	6.6	6.3
Le Shuttle passengers	0.2	4.4	7.9	8.6	12.1	11.0	9.9	9.4	8.6	8.6
CT passengers	0.3	7.1	12.8	14.7	18.4	17.6	17.0	16.3	15.3	14.7

Source: Eurotunnel Annual reports.

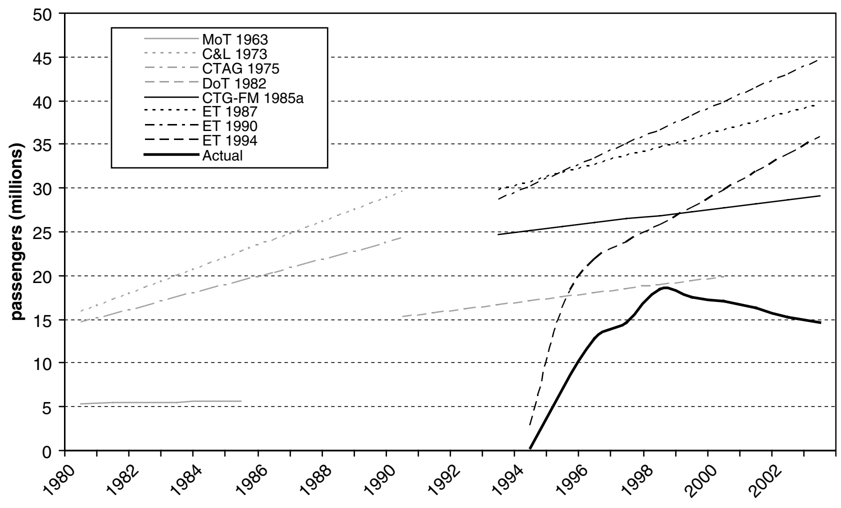


Fig. 1. Channel Tunnel passenger traffic forecasts and actual results (millions of passengers).

4.1.1. Total cross channel market (all modes)

After the opening of the Channel Tunnel, the total number of cross-Channel passengers grew at a considerable pace up until 1998, at which point duty free was abolished. The market then began a process of regression, which continues to the present day (Table 7).

The deviations in the forecasts of the total cross-Channel market are even greater than those for the Channel Tunnel passenger segment (see Fig. 2).[6]

Table 7
Total cross-Channel passengers, 1994–2003 (millions of passengers)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Unaccompanied										
Air passengers[a]	4.4	4.0	4.0	4.3	4.3	4.4	4.3	4.0	4.3	4.1
Eurostar[b] passengers	0.1	2.7	4.9	6.0	6.3	6.6	7.1	6.9	6.6	6.3
Classic passengers subtotal	7.0[c]	6.7	8.9	10.3	10.6	10.9	11.5	10.9	10.9	10.4
Car accompanied										
Ferry services	23.7	21.5	22.4	23.8	20.4	19.0	16.6	16.0	16.5	14.8
Le Shuttle[d]	0.2	4.4	7.9	8.6	12.1	11.0	9.9	9.4	8.6	8.6
Car accompanied subtotal	23.9	25.9	30.3	32.5	32.5	30.0	26.5	25.3	25.1	23.5
Total cross Channel passengers	30.9	32.5	39.2	42.8	43.1	40.9	38.0	36.3	36.0	33.9

Sources: CAA (2004), DHB (2004), DfT (2003, 2004), ET Annual reports.
[a] London—Paris and London—Brussels.
[b] Eurostar operates through-rail passenger services between London and Paris/Brussels.
[c] Includes Sea foot passengers.
[d] "Le Shuttle" is the car, coach and lorry carrying service operated by Eurotunnel.

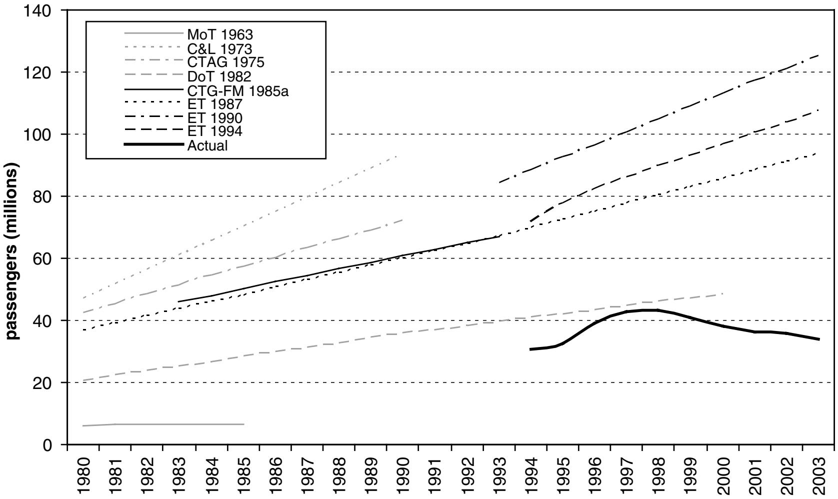


Fig. 2. Total cross-channel passenger traffic forecasts and actual results (millions of passengers).

[6] It is important to note that some of the large differences shown in Fig. 2 are caused by different definitions of the "cross-Channel market". This appears to vary in different studies, ranging from "Dover Straits" to "English Channel" and "Short Sea". Caution is, therefore, necessary in making comparisons.

4.1.2. Channel Tunnel passenger share of the total cross-channel market

The share of the market captured by the Channel Tunnel has exceeded all projections from1998 onwards (Fig. 3). The Tunnel's current market share closely matches Eurotunnel's forecasts of 1987.

4.2. Freight

The actual volume of freight using the Tunnel has experienced significant growth since the start of Tunnel operations (Table 8).

Despite a rather erratic growth pattern,[7] the current volumes of Channel Tunnel freight are higher than Eurotunnel's original forecast (1985) and close to the 1987 estimates.

Eurotunnel's updated forecasts of 1990 and 1994, however, predicted about one third more freight via the Tunnel than the actual levels observed in 2003 (Fig. 4). Again, it is possible to examine the historical evaluations of the total market, as well as the predicted share of the market transported through the Tunnel:

4.2.1. Total cross-channel market

The total cross Channel unitised freight market has seen continued growth since the opening of the Tunnel. However, it stabilised from 2001 at just over 41 million tonnes. Ferry operators have continued to slowly lose market share to Eurotunnel's lorry shuttle.[8]

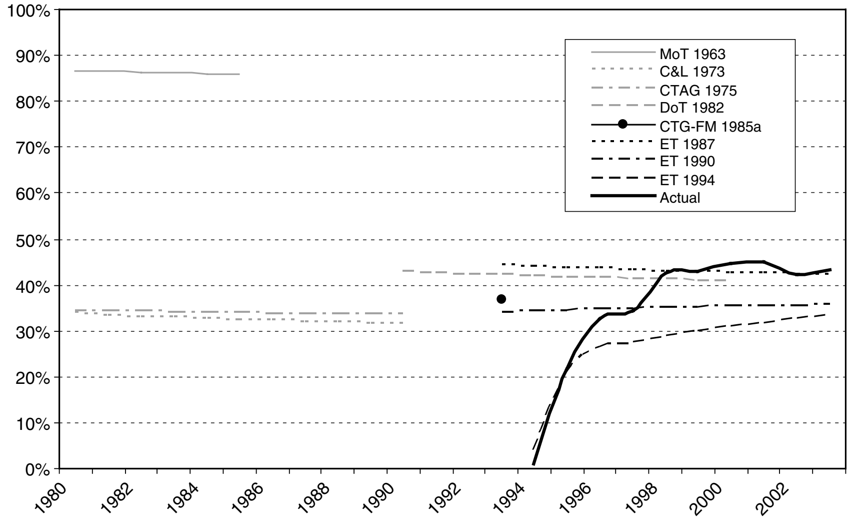


Fig. 3. Channel Tunnel passenger market share forecasts and actual results.

Table 8
Actual channel tunnel freight tonnages 1994–2003 (million tonnes)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Le Shuttle freight	0.8	5.1	6.7	3.3	9.2	10.9	14.7	15.6	15.6	16.7
Through rail services		1.3	2.4	2.9	3.1	2.9	2.9	2.4	1.5	1.7
Total Tunnel freight	0.8	6.4	9.1	6.2	12.3	13.8	17.7	18.0	17.1	18.4

Sources: Eurotunnel Annual Reports.

[7] Channel Tunnel freight volumes decreased significantly in 1997 due to the fire in one of the freight shuttles in November 1996, which caused the closure of the service for 7 months.

[8] In 2003, the Cross-Channel market share of Eurotunnel's freight shuttle was 44%.

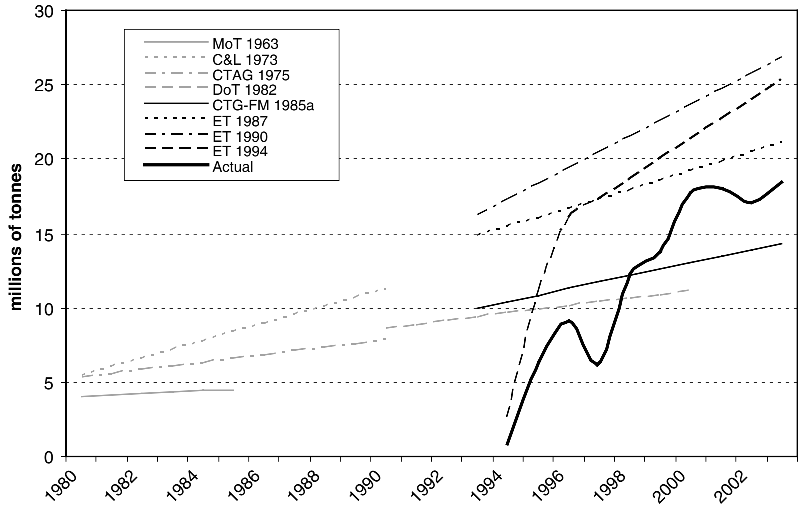


Fig. 4. Channel Tunnel freight forecasts and actual results (million tonnes).

The early cross-Channel unitised freight forecasts appear closer to the actual volumes moved across the Channel (Table 9). ET's projections, however, estimated the market to be nearly double the size of the current freight market (Fig. 5).

Table 9
Cross-Channel unitised freight 1994–2003 (million tonnes)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Channel Tunnel	0.8	6.4	9.1	6.2	12.3	13.8	17.7	18.0	17.1	18.4
Port of Dover	15.1	14.0	13.9	20.8	19.8	21.7	21.0	23.0	24.1	23.2
Total cross Channel	15.9	20.4	23.0	27.1	32.1	35.5	38.7	41.1	41.2	41.6

Source: Eurotunnel Annual Reports, DHB (2004).

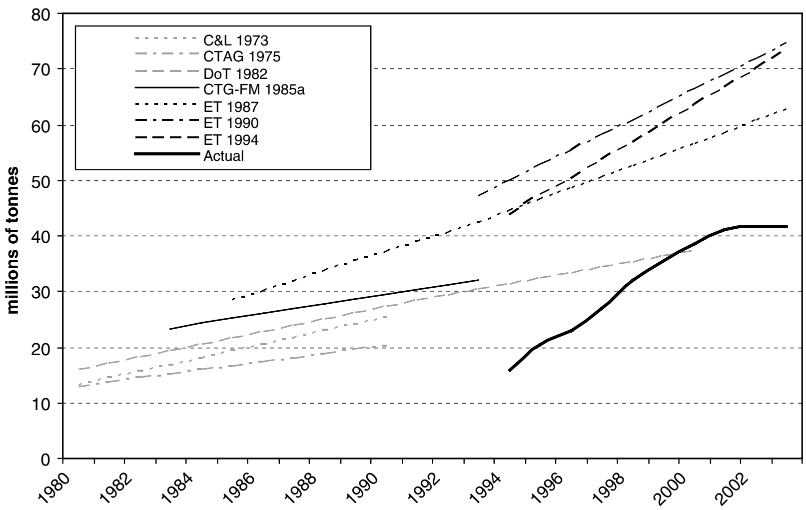


Fig. 5. Total cross-channel freight traffic forecasts and actual results (million tonnes).

4.2.2. Channel Tunnel freight market share

In terms of market share, however, freight through the Channel Tunnel has achieved a significant share of the market, well above all ET's predictions.[9] In fact, it can be seen that Eurotunnel's updates during the construction assumed an increasing larger total market, and that the Tunnel would capture a reduced share; The opposite to what actually happened (Fig. 6).

The graph illustrates how, despite the 1996 fire, the overall cross-Channel market remained unaffected and continued its growth trend, demonstrating the substitutability of the Tunnel by alternative modes (Fig. 7).

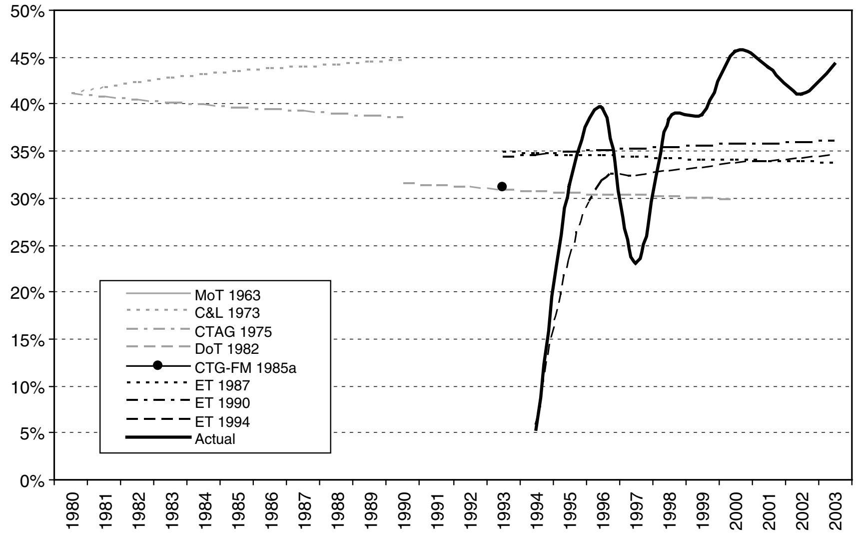


Fig. 6. Channel Tunnel freight market share forecasts.

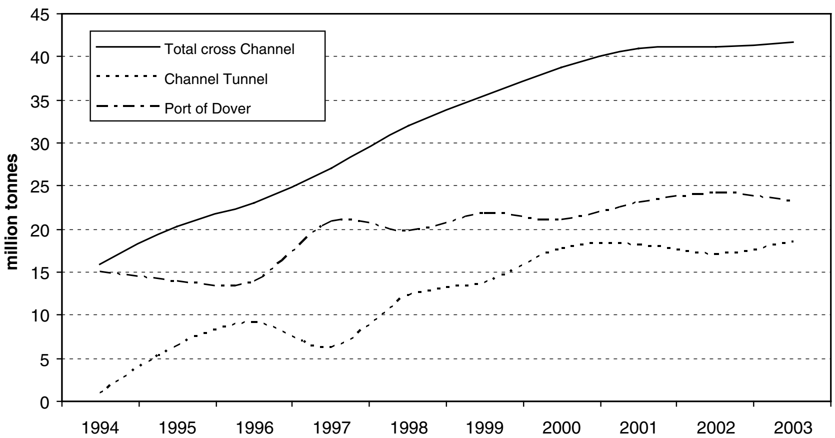


Fig. 7. Cross-channel unitised freight (million tonnes).

[9] With the exception of 1997.

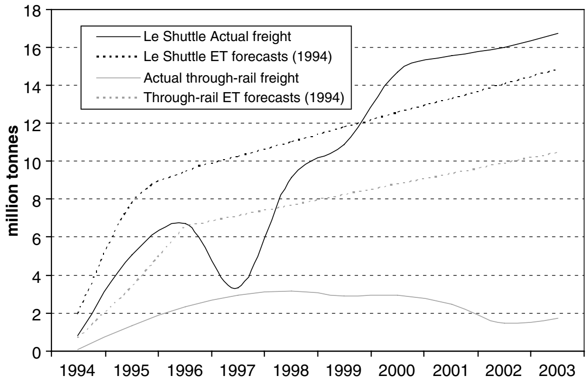


Fig. 8. Le shuttle and through-rail freight forecasts vs actual traffic.

4.3. Discussion

From these comparisons it can be concluded that whilst the predicted rates of diversion have been consistently achieved and, in the case of freight, exceeded, the principal reason why traffic via the Tunnel has historically come short of expectations is the extreme overestimation of the overall passenger and freight cross-Channel markets. It has been suggested (NAO, 2001) that one important contributory factor in recent years has been the unforeseen advent of low cost airlines, which in addition to compete with very low fares, offer more choice of destinations, drawing leisure travellers away from the traditional London–Paris route. Moreover, the availability of such low cost flights from local airports appears to be perceived as an additional advantage.[10] Low-cost airlines carried in 2003 about 50 million passengers (to the whole of Europe).[11] Clearly, many of these passengers will have no relation to the effect described above, which suggests that this cannot provide the complete explanation for the large deviations in the forecasts.

Furthermore, both in the passenger and freight sectors, the market share attained by the tunnel exceeded the 1994 estimates, and by 1998 it exceeded all market share forecasts produced after 1980. Such results were obtained despite some early problems. These are described in some detail when assessing Eurotunnel's revenue.

The case of freight warrants further attention. Not only the actual Channel Tunnel freight volumes are in line with expectations, but the share of the market achieved by the Tunnel is higher than predicted. The volumes of Channel Tunnel freight traffic have been driven by the strong performance of Eurotunnel's Le Shuttle service, which, since 2000 is carrying more freight than predicted by Eurotunnel in 1994 (Fig. 8).

In the case of through-rail freight,[12] the difference between projected and actual tonnages is very significant, and increasing over time.[13]

5. Channel Tunnel appraisal

This section presents the actual costs incurred and revenues earned as a result of the construction and operation of the Channel Tunnel. This is followed by a comparison of these with the historical projections, including an overview of the reasons behind the considerable cost overruns and revenue shortfall. Finally, both ex post financial and cost benefit appraisals of the Channel Tunnel project are undertaken.

[10] As this implies avoiding the need to drive along the generally congested M25 highway around London.

[11] This figure is an indicative estimate. Ryanair (the single biggest low cost carrier in Europe) ceased to be a member of IATA (International Air Travel Association) in 2003.

[12] Eurotunnel has no direct control over through rail services, which are jointly operated by SNCF and EWS.

[13] Despite the disappointing numbers of passengers and freight tonnages carried through the Tunnel on through-rail services, this has not had financial consequences given the existence of the MUC which guarantees a minimum annual revenue to Eurotunnel regardless of the amount of passengers and freight carried during the first 12 years of operation.

The comparisons of cost benefit analyses are particularly difficult. The internal rates of return (IRR) reported in the historical studies ranged between 8% and 18%. However, these can be hardly compared given the differences in the overall appraisal framework, discount rates, appraisal periods, etc.

5.1. Costs

In 2004 prices, the total cost of the construction of the Channel Tunnel and associated equipment is £9456 million (Table 10).

In addition to the Tunnel construction costs, BR incurred significant costs on the development of both its freight and passenger international services. The investment programme involved substantial infrastructure works including of the construction of Waterloo International station, the rebuilding of 94 bridges, extensive upgrading of the SouthEast network, the train servicing depot in West London, freight terminals at Willesden (North London), Trafford Park (Manchester) and Mossend (Glasgow) and new freight operating centres at Wembley and Dollands Moor with an overall cost £1.08 billion. Passenger rolling stock (30 Eurostar trainsets) cost £796 m with a further £202 m invested in freight rolling stock (450 new intermodal and 550 new automotive wagons and 37 new Class 92 locomotives) (Gourvish and Ansen, 2002).

5.1.1. Construction of the channel tunnel and cost escalation[14]

The estimates for the construction costs of the Channel Tunnel by each study followed a marked upward trend between the early 1960s and its final actual costs. This is illustrated in the chart (Fig. 9).

The cost estimates remained under the £4 billion mark until 1980. The CTG–FM's proposal of 1985—to which the concession was awarded—estimated the Channel Tunnel construction costs at £4.74 billion. During the construction period, the costs of construction escalated (late 1980s) and in 1990, Eurotunnel updated its costs prediction, to over £8 billion, more than 62% higher than its own estimate of less than 3 years before. The final construction costs of the Channel Tunnel were £9.5 billion, representing an overall cost increase of 99% over the original 1985 proposal.

The principal reason for the escalation of construction costs was probably the significant constraints on the design and rules imposed by the Independent Safety Authority (created by the two Governments) as the project progressed.[15] This was an inevitable, but nevertheless unusual arrangement, as for most projects, the safety design standards are known in advance. This was one of the risks that was not properly identified by the financiers.

Table 10
Actual Channel Tunnel construction costs

Item	Cost £ million (1985 prices)
Tunnels	2110
Terminals	553
Fixed equipment	1200
Rolling stock	705
Bonuses	46
Direct works	36
Total costs of the system	4650

Source: ET (1994).

[14] This paper identifies the scale, sources and effects of the errors (in terms of the project appraisal), it does not attribute or identify causes on the methodological, social or political aspects of the process.

[15] A number of transport-related incidents (the King's Cross fire, the Clapham Junction train accident, the PanAm 747 crash at Lockerbie, etc.) focused attention on transport safety. These are likely to have resulted in the additional safety features/requirements by the IGC during the construction of the Tunnel.

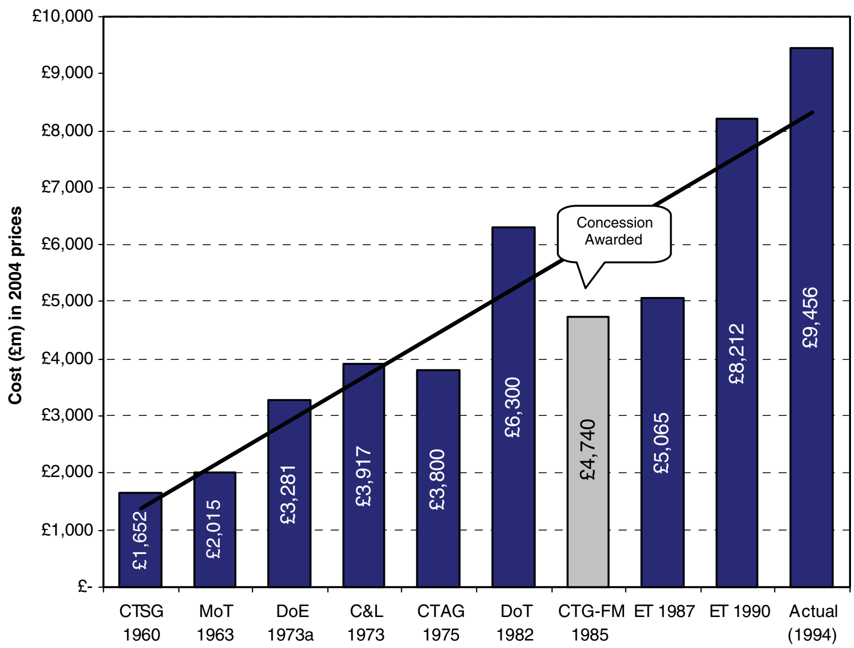


Fig. 9. Channel Tunnel cost projections.

Flyvbjerg et al. (2003) points out two main reasons for the significant cost overruns of the Tunnel. In the first instance it refers to the enhanced safety, security and environmental requirements, highlighting the change of policy or regulation risk often associated with major projects. In addition, it mentions the lack of a clear owner of the project from the outset, emphasising that in proposals for concessions, such as the Channel Tunnel, there may be both short term—construction—and long-term—operations—interests which are likely to diverge.

Indeed, the creation of Eurotunnel as an independent company from the construction consortium TML required the allocation of risks between the companies. The construction contract allocated risk between the contractors and ET in three different ways for different aspects of the work; part fixed cost (with escalation for price changes), part target cost and part cost plus. However, it is still argued (Li and Wearing, 2000) that the contractual arrangements had inadequate incentives and penalty regimes.

As required by *The Concession Agreement* (DfT, 1986), Eurotunnel was established as the operating company with the objective of financing and managing the development of the Channel Tunnel project and to operate the business. ET's first major challenge was to hold the balance between TML and a syndicate of initially 198 banks. Indeed, Eurotunnel's relations with both parties proved very difficult to manage.

The delays in the construction imposed additional financing and labour costs. Furthermore, the unforeseen problems in the works programme required costly modifications and delayed the start of operations which led to the loss of associated operational revenues.

Furthermore, the difficult ground conditions on the British side affected the performance of the tunnel boring machines. This caused delays, required expensive modifications to the machinery and had implications on Eurotunnel's future operating costs. Such a situation led to significant cost overruns, which resulted in additional financing requirements.[16]

[16] Lenders and shareholders were "forced" into further investing so that the project could be completed. In May 1994 (just 2 months before the planned opening of services) £800m of additional equity and £700 m of new debt had to be raised in order to be able to complete the project. (ET, 1994).

5.2. Revenues

As shown above, ET's forecasts of 1994 (ET, 1994) assumed lower numbers of passengers via the Tunnel than its estimates of 1987 and 1990 as well as lower freight volumes than predicted in 1990 (Table 11, Fig. 10). Fig. 11, however, shows that the revenue projections of 1994 were considerably higher than any previous projections. During the construction period, Eurotunnel adjusted its cost projections upwards making use of the emerging cost data available. At the same time, however, and without any clear evidence or justification, the revenue forecasts were also increased by about 20% between 1985 and 1987, a further 10% between 1987 and 1990, and yet a further 27% between 1990 and 1994. This implies that the latter projections assumed much higher unit revenues.

It is clear that Eurotunnel's revenue projections were over-optimistic. There are two main reasons for such a large revenue shortfall. First and foremost, the misjudgement that the overall cross-Channel market would grow much faster than it actually did,[17] and secondly, the failure by Eurotunnel to predict the extent to which alternative services would be able to respond competitively. The result was a fierce price war that greatly reduced the unit revenues earned.

The simple "toll road" operating concept appeared to be highly vulnerable to peak demand overload. In the peak days, long queues formed on both sides of the Tunnel and extended into the motorways. The design

Table 11
Eurotunnel's actual revenue (£m, out turn prices)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Le shuttle	11	120	145	113	210	271	315	310	333	309
Railways[a]	12	133	198	212	213	215	208	211	217	232
Other[b]	7	51	141	206	243	168	77	43	31	43
Total	31	304	483	531	666	654	600	564	581	584

Sources: Eurotunnel Annual Reports.
[a] Railways revenue (Eurostar passenger services and SNCF-EWS through rail freight services) subject to the MUC until 2006.
[b] Includes duty-free sales, telecommunications and other ancillary services.

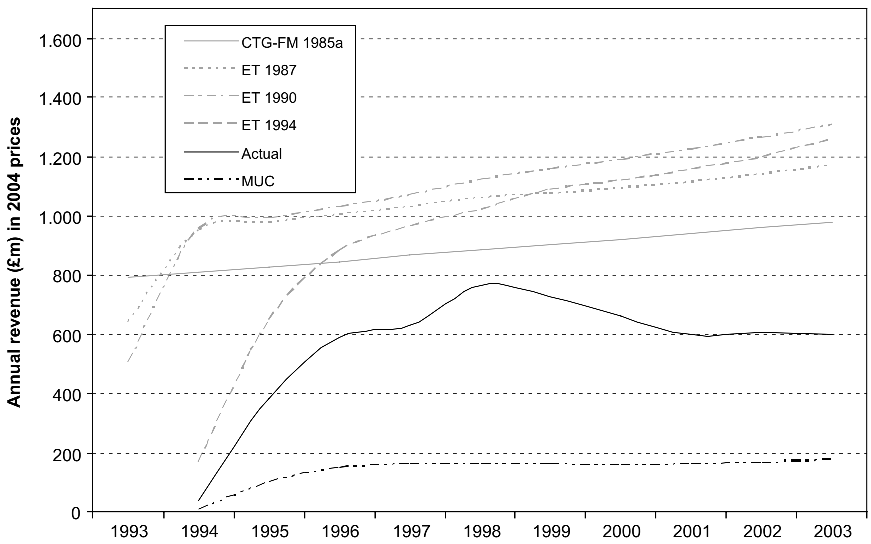


Fig. 10. Eurotunnel's revenue projections and actual results (£ millions).

[17] As described above.

configuration did not allow Eurotunnel the management of demand; neither could it encourage off-peak use. As a result, ET was suffering from peak overload whilst at the same time losing further potential revenue by failing to price discriminate.[18]

ET introduced pre-booking systems in 1996/1997, and the results quickly improved, at least in relation with its ferry competitors. This change in the overall business strategy has profound implications in terms of Eurotunnel's perception of its market position. Eurotunnel finally accepted that it would have to compete with the ferries.

Eurotunnel clearly did not expect such an aggressive reaction from the ferries. The large price reductions had an impact on Eurotunnel's traffic volumes, but even more grave implications for Eurotunnel's revenue streams and for its financial stability.

Soon after the opening of services, Eurotunnel found itself in a price war with the ferry operators and prices quickly fell by an average 35–45%. It became clear that Eurotunnel would not be able to achieve the levels of traffic, and especially the predicted levels of revenue.

5.2.1. Eurotunnel and the cross-channel market

The cross-Channel passenger market is largely a leisure market, consequently, highly discretionary and subject to people's tastes and preferences (Castles, 2003). The leisure market requires constant marketing and promotion to encourage people to choose to take trips. It is very price sensitive because there are many possible substitutes. Eurotunnel's misunderstanding in this sense is illustrated by its original operating concept, which did not allow any price discrimination to match prices to its customers' willingness to pay. In addition, Eurotunnel grossly underestimated its competitors and their potential to significantly cut their prices and still remain in business.

The two issues just mentioned can be illustrated by the 40% price fall in ferry prices achieved in the early 1980s by means of constant competition and offers to beat competitors' prices (enabled by productivity and technological improvements) (Goodwin, 1987).

In this respect, ET's mistake was in ignoring or misunderstanding the capability and response capacity of the ferry services. ET implicitly expected ferry operators to realise the inherent strengths of the Tunnel and most importantly its "permanence". The most important point is the assumption that ferries would concede the market and price levels would be broadly maintained.

In practice, ferry operators competed with each other (as much as they competed with Eurotunnel) by cutting prices to maintain their market share. This was not predatory pricing, but rather fighting for survival. During the construction of the Tunnel, ferry operators invested heavily in new, larger, more efficient vessels and introduced additional efficiency measures.

Castles (2003) argues that ferries made a large proportion of its profits (of up to 50%) from on-board duty-free sales, and therefore had -until the abolition of duty-free in 1998, a very strong incentive to fill vessels to capacity even if this required very low fares.

5.3. User benefits

The estimation of user benefits generated by the Channel Tunnel includes travel time savings as well as the benefits from fare reductions.

5.3.1. Travel time savings

5.3.1.1. Passenger traffic. Travel time savings (penalties) have been calculated for passengers switching from sea and air services, to both Eurostar and passenger shuttle services.

[18] Eurotunnel's competitors had, for many years, been growing its market by segmentation and price differentiation (Castles, 2003). Moreover, Glaister (1976) in *Peak load pricing and the Channel Tunnel,* argued against the proposed operating concept for the Channel Tunnel without any discrimination in price between different traffic types. He suggested an alternative pricing policy that would have resulted in capital cost savings and increased profits. This case study was based on the scheme abandoned in 1975, but the principles and arguments are equally valid given the similarity in the operating concept with the Eurotunnel scheme.

For unaccompanied passengers the time savings (costs) relate to the London to Paris/Brussels journey time by rail compared to former rail-ferry-rail and air services. The time reductions/increases have been adjusted over time as new or improved rail links to airports were introduced. The travel time savings for accompanied vehicles have been estimated in relation to the crossing times via the Tunnel compared with the ferries. In both cases the total journey time has been divided into "in vehicle" time and "waiting" time, and weighted appropriately.

In order to calculate the travel time savings, a number of assumptions have been made. These are consistent with the assumptions used in the calculation of user benefits resulting from fare reductions.

(a) 20% of Eurotunnel's shuttle passengers are assumed to be "generated traffic" as opposed to existing users. These users only benefit from one half of the travel time savings. This is consistent with the "rule of half" theory.
(b) The remaining 80% of shuttle passengers are assumed to have diverted from sea services.
(c) 30% of Eurostar passengers have been assumed to be generated traffic. For the purpose of the travel time saving calculation, 50% of these have been considered as if diverted from air services, the other 50% as if diverted from sea services. The travel time benefits have been calculated applying the rule of half.
(d) All Eurostar business passengers are assumed to have diverted from air services.
(e) Half of Eurostar leisure passengers are assumed to divert from sea services, the other half from air services.[19]

It should be noted that these assumptions probably underestimate the travel time savings of passengers diverting from sea services to Eurostar, as time savings have only been calculated relative to the shortest cross Channel routes (Dover-Calais) (Tables 12 and 13).

Table 12
Passenger travel time savings framework

Car accompanied (all leisure): Eurotunnel's Shuttle	
Passengers diverted from ferries[a]	Number of passengers × $VoT_{leisure}$ × in vehicle journey time reduction
Generated passengers	1/2 × number of passengers × $VoT_{leisure}$ × in vehicle journey time reduction
Unaccompanied passengers: Eurostar	
Passengers diverted from air services	
Business	Number of passengers × $VoT_{business}$ × [(in-vehicle journey time reduction[b]) + (waiting time reduction × 2.5)]
Leisure	Number of passengers × $VoT_{leisure}$ × [(in-vehicle journey time reduction[b]) + (waiting time reduction × 2.5)]
Passengers diverted from sea services	
Leisure	Number of passengers × $VoT_{leisure}$ × [(in-vehicle journey time reduction) + (waiting time reduction × 2.5)]
Generated passengers[c]	
Leisure	1/2 × number of passengers × $VoT_{leisure}$ × [(in-vehicle journey time reduction[b]) + (waiting time reduction × 2.5)]
Leisure	1/2 × number of passengers × $VoT_{leisure}$ × [(in-vehicle journey time reduction) + (waiting time reduction × 2.5)]

[a] Assumes no waiting time saved.
[b] In-vehicle journey time increases for passengers diverting from air services.
[c] The calculation of travel time savings considers 50% of generated traffic as if diverted from air services, the remaining 50% as if diverted from sea services.

[19] If no generated traffic was assumed for Eurostar passengers, this would result in slightly higher results; Whilst the amount of Passenger travel time savings would increase by 5%, the effect on the total user benefits would reduce to 1%. Furthermore, such a change would only improve the results of the CBA by 0.3%.

Table 13
Freight travel time savings framework

Eurotunnel's Shuttle	
Cargo	Number of units (lorries) × $\mathrm{VoT}_{\mathrm{truckload}}$ × journey time reduction
Driver	Number of units (lorries) × $\mathrm{VoT}_{\mathrm{driver}}$ × journey time reduction
Through-rail freight services	
Cargo	Tonnage × $\mathrm{VoT}_{\mathrm{non\text{-}bulk\ freight}}$ × journey time reduction

Journey time reduction applies to cross-Channel leg only.

The calculation of travel time savings has been undertaken using the Department for Transport's (DfT) "Value of Time and Operating Costs" guidance of June 2004 (Table 14). The values of time used in the calculation are:

The value for non-working time (leisure passengers) spent walking or waiting has been weighted 2.5 times as advised by the DfT's guidance.

The values of time have been appropriately adjusted for GDP per capita and inflation to reflect the actual values of time in each year period.

Table 15 shows the resulting travel time benefits generated by the Channel Tunnel.

The much larger contribution to the total passenger travel time savings by passengers diverted from sea services reflects the much larger journey time savings enjoyed by this segment of the market.

5.3.1.2. Freight traffic. The calculation of travel time benefits of freight carried through the Channel differentiates between freight on Eurotunnel's shuttle and through rail freight.

In the case of the lorry shuttle, the travel time savings take into account the benefits both to the cargo and to the driver. The value of time for the driver has been obtained from the DfT's Transport Analysis Guidance (DfT, 2004). In terms of the value of time of cargo itself, the values used are those currently used by the Strategic Rail Authority in freight appraisal (BAH and ITS, 2004).[20]

In both cases the travel time savings apply to the cross-Channel journey only. (i.e. the difference between the cross Channel journey time through the Tunnel and on ferry services). It is recognised that this underestimates the actual time savings, as some of the traffic would have diverted from longer sea routes.

Table 16 shows the estimated user benefits as a result of freight being carried through the Channel Tunnel.

Finally, combining passenger and freight travel time savings, the total travel time benefits as a result of traffic via the Channel Tunnel is shown in Table 17.

Table 14
Values of time per person (£ per hour, 2002 prices and values)

Rail passenger working time	30.57
Non working time "Other"	4.46

Source: DfT (2004).

Table 15
Passenger annual travel time savings 1994–2003 (£m, 2004 prices)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Passengers diverted from air services	0.6	12.9	24.0	30.4	4.4	4.7	5.2	5.3	5.1	5.0
Passengers diverted from sea services	0.8	18.5	34.3	41.6	50.1	50.9	53.0	53.0	50.7	49.9
Generated passengers Subtotal (Eurostar and Shuttle)	0.3	6.1	11.3	14.1	14.0	14.7	15.8	15.9	15.3	14.9
Passenger travel time savings	1.6	37.5	69.6	86.0	68.5	70.3	74.1	74.2	71.1	69.7

Source: Analysis.

[20] These remained not for disclosure at the time of writing.

Table 16
Freight annual travel time savings 1994–2003 (£m, 2004 prices)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Freight on shuttles	0.6	3.5	4.7	2.4	6.8	8.3	11.5	11.9	12.8	13.9
Freight on through-rail services		0.7	1.2	1.6	1.7	1.6	1.7	1.5	0.9	1.1
Freight travel time savings	0.6	4.1	5.9	3.9	8.5	9.9	13.2	13.4	13.7	15.0

Source: Analysis.

Table 17
Total annual travel time savings 1994–2003 (£m, 2004 prices)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Passenger travel time savings	1.6	37.5	69.6	86.0	68.5	70.3	74.1	74.2	71.1	69.7
Freight travel time savings	0.6	4.1	5.9	3.9	8.5	9.9	13.2	13.4	13.7	15.0
Total travel time savings	2.2	41.6	75.6	90.0	77.0	80.2	87.3	87.6	84.8	84.7

Source: Analysis.

Passenger travel time savings represent about 85% of the total. This is driven by the much larger numbers of passengers and, especially, by the more significant journey time reductions applicable.

5.3.2. User benefits from fare reductions

The introduction of a new cross-Channel mode of transport resulted in an increased level of competition which involved significant reductions in fares to consumers. The framework adopted for the welfare analysis is shown in Fig. 11.

5.3.2.1. Passenger traffic. As with the travel time savings, the present calculation assumes 20% of cross-Channel passengers to be "generated traffic". For the purpose of this calculation, this 20% are considered to be the "new users". Passengers diverting from the other existing modes and passengers remaining in ferry services have been considered "existing users". The calculation has been applied to car-accompanied traffic only given that:

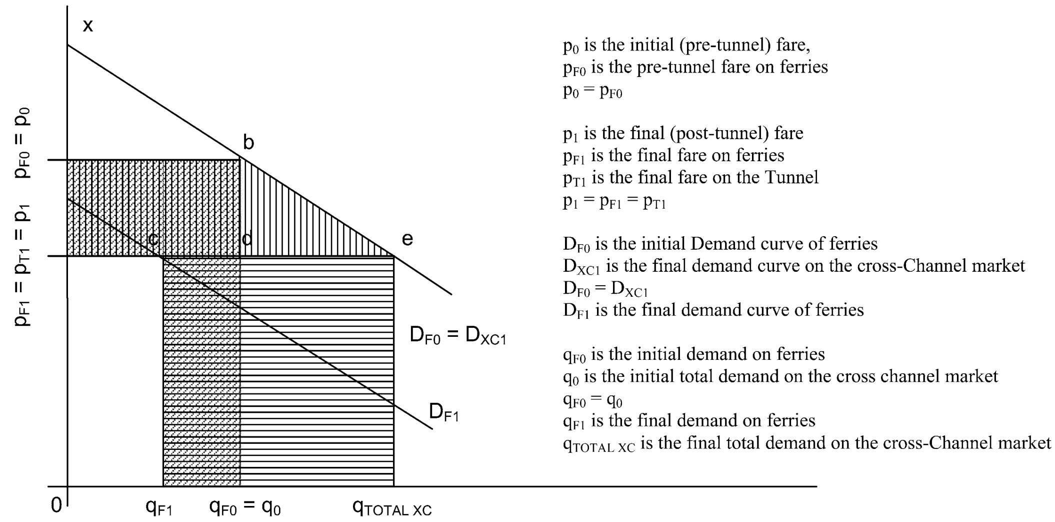
(a) The rail-sea-rail unaccompanied services ceased to operate before the Tunnel was introduced; and
(b) The effect of the Tunnel on air fares reductions is more than questionable given the substantial changes that the industry has seen in recent years following the liberalization of the EU market and the advent of low cost airlines.

Average fares for the shuttle have been derived from revenue and numbers of vehicles data as published by Eurotunnel, using revenue split data and numbers of trips per category and using weighted averages (car shuttle, coach and bus and lorry shuttle). Average ferry fares have been assumed to be equivalent to the Tunnel.

The benefit to existing users has been assumed to be equal to the average price reduction resulting from the introduction of the Tunnel. As explained above, the definition of existing users includes all Dover Straits cross-Channel traffic. The benefit to generated traffic has been calculated as one half of the average of the price reduction times the number of new users. This methodology for calculating the change in consumer surplus follows the well established rule of half. This has been applied on a yearly basis.

Table 18 presents the estimated user benefits from fare reductions that resulted from the opening of the Channel Tunnel.

The decrease in annual consumer surplus beyond 1998 reflects the price increases by both Eurotunnel and ferry operators following the abolition of duty-free.



Ferry producer's loss, made up of

- lost traffic × original fare: $(q_0 - q_{F1}) \times p_0$, in turn made of:
  - Transfer from Ferries Producers to Consumers (*abdca*): and
  - Transfer from Ferries to Tunnel ($cdq_0q_{F1}c$)

-retained traffic × fare reduction: $q_{F1} \times (p_0\text{-}p_1)$
  - Transfer from Ferries to consumers ($p_0acp_1p_0$)

Tunnel producer gain:

-Tunnel revenue ($cdeq_{TOTAL\ XC}q_0q_{F1}c$)

Consumer benefit ($Xbedcp_1p_0X$), made up of

-Transfer from ferry Producer to Consumers: original users × fare reduction, ($p_0abdcp_1p_0$): and

-Consumer surplus: ½ × additional traffic × fare reduction (*bedb*)
  - ½ × $(q_{TOTAL\ XC} - q_0) \times (p_0 - p_1)$

Therefore, the actual net benefit is ($cgq_{TOTAL\ XC}q_0fc$), made up of

-Producer surplus: ($deq_{TOTAL\ XC}q_0d$); and

-Consumer surplus: (*bedb*)

Fig. 11. Consumer and producer benefits framework.

Table 18
Car-accompanied passengers fare reduction benefits 1994–2003 (£m, 2004 prices)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Existing users	45.0	71.8	143.9	165.8	208.3	158.7	89.9	85.1	60.2	60.2
New users	5.6	9.0	18.0	20.7	26.0	19.8	11.2	10.6	7.5	7.5
Total car-accompanied	50.6	80.7	161.9	186.5	234.3	178.5	101.1	95.8	67.7	67.7

Source: Analysis.

5.3.2.2. Freight traffic. The user benefits resulting from the fares' reductions caused by the opening of the Tunnel have been estimated following an equivalent approach to the calculation referent to passengers.

The calculation has been applied to unitised freight traffic only (i.e. excluding through rail freight given the unavailability of data).

In this case, however, no traffic has been assumed to have been generated by the construction of the Channel Tunnel. This stems from the fact that the freight market is driven by macro-economic factors and the evolution of international trade patterns, as opposed to the passenger leisure market, which is highly discretionary and price sensitive. As a result, all unitised freight through the Tunnel and via Dover has been considered to be "existing traffic". Average lorry shuttle prices have been derived from ET's published data on revenues, traffic volumes and percentage of revenue generated by the lorry shuttle. Freight shuttle and ferry price reductions have been assumed to be equivalent over time.

The results of the estimated unitised freight benefits from fare reductions are presented in Table 19. In this case, the beneficial effect of the opening of the Tunnel is even more accentuated. This results from the price war and substantial reductions that followed the opening of the Tunnel.

Freight rates have remained substantially lower than pre-tunnel levels. This and the continuing growth in overall cross-Channel volumes are the drivers behind the large consumer surplus generated by the freight market.

The total estimated user benefits from fares reductions generated as a result of the opening of the Channel Tunnel is given in Table 20.

It can be observed that up until 1998, passenger and freight generated equivalent levels of fare reductions' benefits. From 1999, the freight shuttle generates greater benefits, as a consequence of the increases in car-passenger prices and the continuing growth in freight movements.

5.3.3. Total user benefits

Total user benefits generated by the construction of the Channel Tunnel in terms of travel time savings and fare reductions are presented in Table 21.

The total user benefits generated by the Channel Tunnel grew until 1998, driven by growing passenger and freight benefits. Beyond 1998, the amount of user benefits has remained broadly stable at around £500 m. It can be seen that the benefits resulting from fare reductions account for about four times the travel time savings. This illustrates the extent of the transfer from Producers to Consumers. It has been suggested (Castles,

Table 19
Unitised freight traffic fare reduction benefits 1994–2003 (£m, 2004 prices)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Unitised freight	63.1	90.1	159.9	161.4	224.4	228.2	291.3	367.1	352.1	342.3

Source: Analysis.

Table 20
Total user benefits as a result of fare reductions 1994–2003 (£m, 2004 prices)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Car-accompanied	50.6	80.7	161.9	186.5	234.3	178.5	101.1	95.8	67.7	67.7
Unitised freight	63.1	90.1	159.9	161.4	224.4	228.2	291.3	367.1	352.1	342.3
Total fare reductions benefits	113.7	170.9	321.7	347.9	458.7	406.7	392.5	462.9	419.8	409.9

Source: Analysis.

Table 21
Total user benefits 1994–2003 (£m, 2004 prices)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Total travel time savings	2.2	41.6	75.6	90.0	77.0	80.2	87.3	87.6	84.8	84.7
Total consumer surplus	113.7	170.9	321.7	347.9	458.7	406.7	392.5	462.9	419.8	409.9
Total user benefits	115.8	212.5	397.3	437.9	535.7	486.9	479.7	550.5	504.6	494.7

Source: Analysis.

2003) that before the opening of the Tunnel, ferry operators enjoyed monopolistic profits. In this situation it is at least valid to question whether such a transfer would be a real economic benefit (as it implies that pre-Tunnel fares were uneconomic).

5.3.4. Comparison with historical projections

The comparison between historical estimates of user benefit and the present calculation is particularly difficult. This results from the lack of consistency in the benefits included in the calculations, for example with different appraisal periods and discount rates, and the different approaches used. Some studies did not consider user benefits. Furthermore, the difficulties increase given the way the results have been presented over the years. In general, the calculation of user benefits is provided as an aggregate net present value.

Table 22 summarises the approach adopted in the historical studies that did quantify user benefits including the parameters used for this calculation. The NPV calculated in each case is also included, although the comparison is not possible given the differences in the parameters. The approach and results of the present study are also included.

5.4. Producers' losses

The losses to producers—ferry operators—resulting from the opening of the Channel Tunnel have also been estimated. These have been calculated as the foregone revenues as a result from the introduction of the Channel Tunnel in terms of both the reductions in fares—which applies to the traffic retained by the ferry operators—and the traffic lost to the Tunnel. Traffic generated has been excluded from the calculation (Table 23).

Table 22
Summary of historical calculations of user benefits

Report	References	Approach to user benefits calculation	Appraisal period (years)	Discount rate (%)	Price base	Net present value of user benefits (£m)
Proposals for a fixed Channel link	MoT (1963)	Only the user benefits resulting from generated traffic were considered. These included producer surplus and consumer surplus (fare reductions)	50	7	1962	£54 m
The Channel Tunnel: A UK transport cost benefit study	C&L (1973)	User benefits were calculated in terms of travel time savings and fare reductions. In the former, separate estimates were provided for business, non-business and freight traffic. The value of time for business trips appears to be much lower than the current figures applicable, whilst the freight values of time seem very much in line with current practice	50	10	1973	£171 m
The Channel Tunnel and alternative cross Channel services	CTAG (1975)	The Channel Tunnel Advisory Group estimated the benefits resulting from changes in fares and travel time savings	55	10	1973	£70 m
Fixed Channel Link	DoT (1982)	The 1982 UK–French study estimated the travel time savings only (double 7-metre diameter tunnel option)	50	7	1981	£183 m
Present study		Travel time savings and benefits from fare reductions	16	3.5	2004	£2777 m

Table 23
Passenger traffic producers' loss 1994–2003 (£m, 2004 prices)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Retained traffic	43.9	50.4	85.6	100.4	103.3	76.1	43.4	42.8	31.9	32.0
Lost traffic	5.3	79.7	135.4	151.1	218.4	212.5	181.5	164.9	152.3	148.5
Passenger traffic Producers' loss	49.2	130.2	221.0	251.5	321.8	288.6	224.8	207.7	184.2	180.5

Source: Analysis.

Table 24
Freight traffic producers' loss 1994–2003 (£m, 2004 prices)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Retained traffic	59.7	66.1	107.7	139.2	153.4	151.8	171.3	219.1	211.6	198.9
Lost traffic	17.7	106.2	140.9	69.5	191.4	227.8	307.7	325.3	334.3	348.9
Freight traffic Producers' loss	77.4	172.3	248.7	208.7	344.8	379.6	479.1	544.3	545.9	547.8

Source: Analysis.

Table 25
Total producers' loss 1994–2003 (£m, 2004 prices)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Passenger traffic	49.2	130.2	221.0	251.5	321.8	288.6	224.8	207.7	184.2	180.5
Freight traffic	77.4	172.3	248.7	208.7	344.8	379.6	479.1	544.3	545.9	547.8
Total Producers' loss	126.6	302.4	469.7	460.2	666.6	668.2	703.9	752.0	730.1	728.3

Source: Analysis.

The same approach has been applied to the freight market. The losses in this case are much more significant, given the good performance of the Tunnel in this sector and the sustained low fares after the opening of the Tunnel (Tables 24 and 25).

5.5. *Ex post financial appraisal and transport cost benefit appraisal*

The transport cost benefit analysis and financial appraisal have been undertaken considering the actual performance of the Tunnel to the present day (ex post), and as such, the appraisal period runs from the start of the construction of the Channel Tunnel in late 1987 to the end of 2003.

5.5.1. *Transport cost benefit appraisal*

The cost benefit analysis (CBA) has been performed exclusively in transport terms, with the scope of the analysis limited to the direct resource costs concerned with the construction and operation of the link. The CBA also includes the results from the welfare analysis as described above,[21] but excludes wider factors such as environmental impacts, effects on employment, regional and distributional issues and energy saving effects. It is not, therefore, a full cost benefit appraisal.

The appraisal excludes any financing costs (interest charges, etc.). All figures are in millions of pounds (£m) at 2004 prices. The net present value (NPV) in 1987 has been calculated using the current discount rate of 3.5% as established by the HM Treasury (2003) (Green Book).

With a very large negative net present value, the Channel Tunnel project clearly has, up to the present day and in cost benefit terms, not been a viable project (Table 26). This is driven by a number of factors; first and foremost the fact that the tunnel has been operational only for 10 years, and the limited appraisal period has a

[21] Travel time savings, benefits from fare reductions and Producer's losses.

Table 26
Ex post cost benefit analysis, 1987–2003. Discounted at 3.5% p.a. to 1987 (£m, 2004 prices)

Channel Tunnel costs	
Capital costs	−8443
Operating costs	−2443
Subtotal Tunnel costs	−10,885
BR investment costs	
Infrastructure	−928
Passenger rolling stock	−683
Freight rolling stock	−174
Subtotal BR investment costs	−1785
Total costs[a]	−12,670
Channel Tunnel revenue	
Shuttle	1531
Railways[b]	1228
Other	797
Subtotal Tunnel revenue	3557
User benefits	
Travel time savings	468
Consumer surplus	2309
Subtotal user benefits	2777
Total benefits	6334
Producers' losses	−3669
Net present value (1987)	−10,006

Source: Analysis.
[a] Excludes French (SNCF) investment required in associated infrastructure works, traction and wagons.
[b] Excludes the UK element of the Freight part of the MUC and OPEX payments, as these are directly subsidised by the Government and simply represent a transfer.

very significant impact on the appraisal. Other factors driving the negative NPV are the large initial capital costs and the very significant producer's losses.

5.5.2. *Eurotunnel financial appraisal*

A financial appraisal has been undertaken using exclusively the costs and revenues accruing to Eurotunnel. Consequently, this excludes BR's investment costs and any unpriced benefits but includes all MUC payments to Eurotunnel (regardless of how they are funded). The financial appraisal illustrates the extent to which Eurotunnel is currently in financial difficulties (Table 27). Assuming a private sector required rate of return of 12%, the results of the financial appraisal to the present day are:

The financial appraisal of the Channel Tunnel to the present day gives a negative NPV of £6 billion. The assumed rate of discount does not materially impact on the calculation. In fact, if a 3.5% rate was used, the

Table 27
Ex post financial appraisal, 1987–2003

Channel Tunnel costs	−7465
Channel Tunnel revenue	1477
Net present value (1987)	−5988
Internal rate of return	−14.45%

Discounted at 12% p.a. to 1987 (£m, 2004 prices).
Source: Analysis.

results would slightly worsen because the very large negative cash-flows incurred during the construction years would be discounted to a lesser degree.

5.5.3. Long-term appraisal

A final calculation has been considered to illustrate the long-term prospects of the Channel Tunnel. It is important to note that these forward looking appraisals are based on very broad and basic assumptions on the conditions and evolution of the cross-Channel market. The main assumption is one of steady state, with stability in the operating unit costs and prices (in real terms). The long term appraisal uses a 65-year time horizon (1987–2052). This is the period during which the current arrangements are valid.[22] Two scenarios are considered:

(a) The current debt size and structure remains. In this situation, in order to obtain a positive net present value, in cost benefit terms, passenger and freight volumes would need to grow at an annual rate of 10%. This is clearly unachievable given the limited capacity of the tunnel, and more importantly the size of the market.
(b) The Channel Tunnel debt is written off. This calculation considers only revenues over and above operating costs of Eurotunnel after allowing for depreciation[23] of renewable assets,[24] and assumes traffic volumes to remain at 2003 levels (i.e. no growth). In this situation, the long-term financial appraisal of the Tunnel renders a positive net present value of just over £2 billion.[25] Given the assumptions described above, the NPV of the Tunnel operator would remain positive even if revenue were reduced by up to 35%, for example as a result of a continued price war with ferry operators.[26] This result illustrates the strong competitive position of the Tunnel operator in these circumstances, however also indicating the potential vulnerability to continued price battles with its competitors.

6. Summary and conclusions

The construction of the Channel Tunnel involved a long and difficult decision making process expanding over 25 years. Once the Governments decided to proceed with the project, the actual construction of the Tunnel was disrupted by significant financial difficulties that nearly led to the collapse of the project well before it started operations.

The Channel Tunnel is a complex project in every sense. It links Britain to the Continent 40 m under the seabed. It was privately financed under a concession from the two Governments. This is reflected in the complex matrix of contractual agreements involving UK and French, public and private interests. This was further complicated by the privatisation of British Rail.[27]

It is clear that the forecasts were overly optimistic, especially with regards to the size and growth of the total cross-Channel markets. Whilst in recent years, low cost airlines have had an impact on overall cross-Channel traffic, the size of the market served by these suggest that this provides only part of the explanation.

The market shares captured by the Tunnel were predicted reasonably well, although these apply to a much smaller market base. The freight shuttle has been the best performing of the Tunnel services. These, however, were only achieved through a competitive battle with ferry operators which resulted in reduced tariffs. The combination of lower tariffs and a smaller market resulted in revenues much lower than predicted.

[22] The RUC runs until 2052. Whilst the Concession was extended until 2086, for the final 34 years, the access regime has not been defined.
[23] Depreciation charges have been calculated based on Eurotunnel's depreciation policy, but only applied to renewable assets. These include rolling stock, fixed equipment and machinery, but exclude tunnels and terminals.
[24] It has been assumed that these assets would be renewed on a like-for-like basis, (i.e. without capacity expansion) and with prices remaining stable in real terms.
[25] Discount rate: 12%.
[26] Assuming that the operating costs remained at a similar level.
[27] And the non-privatisation of SNCF.

For completely separate set of reasons, the construction costs of the Tunnel doubled. The overall shortfall in traffic volume, the escalation of construction costs and the price reductions as a result of the competitive battle are the main factors affecting Eurotunnel's finances.

The cost benefit appraisal of the Channel Tunnel reveals that overall the British economy would have been better off if the Tunnel had never been constructed, as the total resource cost has been greater that the benefits generated. Moreover, the project required the investment of very large amounts of financial and labour resources.

Instead, strong competition policies could have been enforced on the Cross-Channel ferry industry. Once the Tunnel has been constructed, the maximum benefits might be obtained if Eurotunnel was able to operate without its current debt burden, charging economic prices. From the analysis it is not immediately apparent that there would necessarily be net benefits in closing it now.

Whilst for consumers the Tunnel has brought large benefits in the form of increased competition and reduced prices for both passengers and freight, this, however, has come at the great expense of producers. The latter, both ferry operators and the Tunnel operators have lost. And its loss outweighs the user benefits significantly. It appears remarkable that the single biggest component of users gain has not, as expected, been in terms of travel time savings, but due to the transfer from producers. In this sense, the project has to be regarded as close to disastrous for its investors; the current share price stands at £0.18[28] and the short to medium term prospects are not encouraging.

The longer term evaluation of the project confirms the poor viability of the investment both in financial and cost benefit terms as well as the bleak future prospects for shareholders and lenders. The history of the Channel Tunnel is one of multiple problems and difficulties. These occurred before, during and after the construction of the Tunnel. Whilst current performance generates some operating profit, the large debt accumulated over the years makes the project financially unsustainable. The Channel Tunnel has been recognised as an excellent piece of engineering. Its financial future, however, remains uncertain.

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Bread or Games?: A Social Cost–Benefit Analysis of the World Cup Bid of the Netherlands and the Winning Russian Bid

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Abstract

Many countries compete fiercely for the right to host mega-events like the World Cup. Proponents of hosting mega-events claim that yields economic gains. Many available studies focus on partial effects of hosting or concern ex post analyses. The authors utilize the existing literature to perform a detailed cost–benefit analysis (CBA) of the Netherlands bidding jointly with Belgium for the 2018 World Cup. The authors show that national pride and pleasure come at a price and financial gains are unlikely. Based on this CBA, the authors predict that the costs of the 2018 World Cup in Russia will also exceed the financial benefits.

Keywords

cost–benefit analysis, mega-event, FIFA World Cup, sports economics

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Introduction

Several countries, among which the United States, England, Russia, and Japan, competed to organize the 2018 and 2022 World Cups. Ultimately, the hosting of the 2018 World Cup was awarded to Russia and the 2022 event to Qatar in a tumultuous election in December 2010. One of the arguments a bidding committee uses to get support from its national government is that hosting a major tournament is economically attractive. Whether hosting the World Cup actually benefits welfare is the research question of this article. We investigate this for the Netherlands, which bid to host the 2018 or 2022 World Cup jointly with Belgium. According to the proponents, organizing the event would have benefits exceeding the costs and, in addition, benefit the image of the Netherlands and promote tourism and economic growth. Furthermore, hosting a World Cup is often assumed to contribute to national pride and joy. However, organizing the World Cup is not a free lunch; it requires heavy investments in, for example, stadiums and security.

This study explores the possibility of making an accurate *ex ante* social cost–benefit analysis (CBA) of major sports events and drawing conclusions for future events. The social CBA focuses on holding the World Cup in the Netherlands and Belgium. The results show that the costs exceed the financial benefits. The event does offer a number of nonfinancial benefits, particularly national pride. If the Netherlands had decided to bid solo, the appreciation of nonvalued benefits would have needed to be considerably higher in order to make the event socially beneficial. Extrapolating this Dutch CBA to the winning Russian bid, we show that the costs will most likely outweigh the financial benefits to an even larger extent.

The study focuses on the welfare effects of hosting a mega-event on the bidding country. As such, the study is of limited importance to the Fédération Internationale de Football Association (FIFA) because in the decision process of granting the organization of the World Cup, FIFA will most likely focus on maximizing its own utility.

This study deviates from the literature in several respects. To the best of our knowledge, this is the first attempt to use social CBA to chart all the effects of a major sports event *ex ante*. This is also the first study to be conducted with the explicit inclusion of governmental costs associated with preparation and security. Finally, it is the first analysis to account *ex ante* for the effects of crowding-out on tourism. This study also differs from the *ex ante* studies made in the United Kingdom and the United States prior to bidding for the 2018-2022 World Cup. Coates (2010) points out a number of shortcomings of a study by the U.S. bidding committee, such as the fact that World Cup related spending by residents is included in the figures. PriceWaterhouseCoopers (2009) made an economic impact assessment of the World Cup in the United Kingdom, but they confuse costs with benefits on a number of occasions (e.g., expenditures on infrastructure and security). We will take these pitfalls of previous *ex ante* studies into account in our analysis.

The Economic Impact of Sports Events section briefly discusses the academic literature regarding the impact of major sports events, particularly the 2006 World Cup in Germany. The Social CBA of World Cup in the Netherlands section presents the social CBA of the World Cup in the Netherlands, and the Outcome of the Social CBA section presents the overall results. A Frame of Reference: Bidding Solo and the 2018 World Cup in Russia section compares the Dutch–Belgian bid to the winning Russian bid and discusses how a Dutch solo-bid would have performed. The Conclusion section provides some discussion and policy implications.

The Economic Impact of Sports Events

Estimates of the impact of major sports events differ widely across studies, even for the same event, and the effects found in *ex post* studies are much smaller than those found in *ex ante* studies (Matheson, 2006). On the other hand, the costs of infrastructure, facilities, preparation, and security are often underestimated, if they are included at all. Another problem is that studies often adopt an input/output approach, in which the initial surge in spending increases due to a multiplier effect. This could double the estimated impulse. Such multipliers do not consider any tendency toward a general equilibrium but assume that existing economic relationships will remain constant. This leads to an overestimation of the welfare effects. Moreover, many *ex ante* studies predict major employment benefits that are extremely difficult to find afterward (Hagn & Maennig, 2007; Kavetsos & Szymanski, 2010). If there are any employment benefits at all, they are likely to be small and temporary, and for unskilled labor in particular (Maennig, 2007).

Matheson (2002, 2006) concludes that six effects are often estimated too positively or even completely forgotten in *ex ante* studies: (a) the substitution effect: expenditures related to the tournament are considered extra, while expenditures that are not related to the event decline; (b) time-switching: people who attend an event would have come anyway, but at another time; (c) crowding-out effects with regard to tourists; (d) leakage effect: many expenditures on or during events do not remain in the local economy but are transferred to the international sports federation; (e) the benefits of investments after the event; (f) not all effects are considered (e.g., traffic congestion, construction-related inconvenience, vandalism, environmental pollution, and disruptions of the residents' life).

The World Cup 2006 held in Germany received the most extensive examination in the literature. This event provides a relevant benchmark for a proposed World Cup in the Netherlands and Belgium. In its final report (Bundesregierung, 2006), the federal government of Germany concludes that the World Cup was successful and that the financial results exceeded expectations. However, the report does not consider the individual states, which bore a considerable proportion of the costs of stadium expansion and security. Nonfinancial effects are completely ignored. Profits from the 2006 World Cup for FIFA amounted to €1.4 billion.[1] Estimates of the expenditures of foreign tourists during the 2006 World Cup Germany range from €500 million (Brenke & Wagner, 2007a) to €3.2 billion (Kurscheidt, Preuss, & Schütte, 2008). Moreover, Brenke and Wagner (2007b) discuss a range of reasons why Kurscheidt, Preuss, and Schütte (2008) overestimate tourist spending. Maennig (2007) and Preuss (2007) argue that the positive effects should be sought primarily in nonfinancial matters, such as improvements in the infrastructure, stadiums and Germany's image abroad, strengthening of the German identity, and so on. Ohmann, Jones, and Wilkes (2006) conclude that local residents generally appreciated the urban development, increased security, and the atmosphere that came with the World Cup. None of the discussed studies analyzes the costs and benefits. Only partial effects are investigated, and the nonmonetary costs and benefits are addressed to a much lesser extent. The estimates of the surge in spending vary widely in quality and robustness. It is therefore difficult to assess whether the 2006 World Cup was good for German welfare.

The Social CBA of the World Cup in the Netherlands

Design of the Social CBA

This social CBA aims at charting all the effects impacting the welfare of the Netherlands hosting the World Cup jointly with Belgium in 2018 or 2022.[2] The counterfactual is that the 2018 and 2022 World Cups will not be organized in the Netherlands (and Belgium), but in another European country.[3] Three sets of estimates were made: a most likely estimate and two scenarios which delineate the bandwidth. At one extreme is a favorable scenario, in which the estimated costs are low and the estimated benefits are high. At the other extreme is an unfavorable scenario, in which the estimated costs are high and the estimated benefits are low. The effects were estimated for each year from 2010 through 2019, and discounted to values for 2010 using a discount rate of 5.5%, which is customary for government projects in the Netherlands.[4]

Domestic expenditures have a different impact on Dutch welfare than impulses from abroad. Domestic expenditures (e.g., expenditures for stadiums, security, and infrastructure) will be compensated by less spending elsewhere in the Dutch economy, either simultaneously or later. Therefore, domestic expenditures do not increase gross domestic product (GDP). Additional spending from abroad (e.g., by foreign tourists and FIFA), on the other hand, does increase Dutch GDP.

Additional expenditures cause additional production through multiplier effects. Using input–output tables, we indicatively computed a multiplier of about 2. However, additional production also implies additional costs of labor and capital. Including tentative estimates of these costs showed that the net welfare effect is roughly equal to the additional expenditures, leading to a net multiplier of 1.

Investments in Stadiums and Infrastructure

A World Cup usually involves heavy investment in stadiums. For example, Germany invested approximately €1.4 billion in the 12 stadiums used for the 2006 World Cup (Maennig, 2007). For the 2008 European Championships, Austria invested €136 million in the four match venues (Helmenstein & Kleissner, 2008).

The 2018 World Cup will be played in a minimum of 10 (and probably 12) stadiums (International Federation of Association Football [FIFA], 2009). The investments in stadiums in the Netherlands are presented in Table 1. The new "Kuip" in Rotterdam would require the largest investment. There is a possibility that this stadium will be realized even without the World Cup but considerably smaller and later in that case.

Table 2 presents the total costs and benefits of stadium investments. New sports arenas tend to have a positive impact on attendance (Leadley & Zygmont, 2005; Maennig, 2007). Moreover, Falter, Pérignon, and Vercruysse (2008) show empirically that performing well in the World Cup in 1998 gave the French league a substantial boost in terms of average match attendance, although this effect depends on the performance of the national team rather than on being the host. Only that part of the stadium investments that will be built solely on account of the World Cup is relevant to the analysis. Stadium investments that are profitable even without the World Cup, for example, because of average match attendance growth, will most likely be realized anyway. Capacity investments also realized without World Cup are not included in the costs of the event. Based on expected attendance, the central scenario assumes that investments done for the World Cup will only generate benefits about half the size of the costs after the tournament. Because of uncertainty concerning this figure in the favorable scenario, the net costs are assumed to be 25% lower than in the central (probable) scenario; in the unfavorable scenario, they are 50% higher. Preuss (2004) used data from three Olympic Games to calculate the average distribution of investments over time for major sports events. This distribution is used to discount the costs to the base year of 2010 (see the last column in Table 2).

In most cases, major sports events are accompanied by hundreds of millions of euro's for infrastructural investments. For example, in addition to investing €1.4 billion in stadiums, Germany invested €2 billion in infrastructure for the 2006 World Cup (Maennig, 2007). However, it is often not clear whether these investments would have been realized or approved without the World Cup. In many cases, officials use major sports events to accelerate projects. Projects that would not otherwise be realized are likely to have more costs than benefits. The current infrastructure in the Netherlands is generally claimed to suffice for hosting the World Cup, rendering additional investments not necessary. Additionally, considered that no projects for the World Cup are in progress yet, it is virtually impossible that they will be realized in time. Therefore, we include zero net cost of infrastructure investments in the probable and favorable scenarios. In the unfavorable scenario, additional investments are included as a negative nonmonetized item.

Table 1. Investments in Tournament Stadiums.

City	Stadium	Capacity (Gross) Demanded by FIFA	Current Capacity	Autonomous Capacity Growth	Additional Seats for the World Cup	Investments Excluding Autonomous Capacity Growth (€ Million)
Amsterdam	Olympic Stadium	45,000	22,000	0	23,000	22.5[a]
Amsterdam	Amsterdam ArenA	65,000	51,500	3,500	10,000	80
Rotterdam	The Kuip	45,000	51,500	0	0	0
Rotterdam	The new Kuip	85,000	0	0	85,000	600
Eindhoven	Philips Stadium	45,000	35,000	0	10,000	80
Heerenveen	Abe Lenstra Stadium	45,000	26,000	6,000	13,000	40
Enschede	De Grolsch Veste	45,000	23,500	9,000	12,500	40[a]

Note. Estimates by municipalities, in consultation with the stadiums; Netherlands Ministry of Health, Welfare, and Sport (VWS). FIFA = International Federation of Association Football.
[a]Temporary capacity, without later use or benefits apart from the proceeds from re-use as mentioned in Table 2.

Table 2. Costs and Benefits of Stadium Adaptations (×€ Million).

Scenario	Number of Tournament Stadiums	Total Investments	Profitable Part of Investments	Unprofitable Part of Investments	Unprofitable Part of Investments, Incl. Uncertainty Margin	Proceeds From Re-Use of Temporary Expansions	NPV of the Net Costs of Stadium Adaptations
Favorable	5	720	340	380	285	6	−188.6
Probable	5	800	380	420	420	6	−279.8
Unfavorable	7	862.5	0	862.5	1,293.8	0	−873.2

Note. In the probable scenario 50% of the investment in a permanent extension is beneficial. The favorable scenario entails 25% lower costs than the probable scenario, the unfavorable scenario 50% higher costs. NPV = net present value.

Costs for the Government: Security and Preparation

Security is one of the most important cost items involved in a World Cup. Yet, to our best knowledge, these costs have never been estimated. Security within the stadiums is the responsibility of the organizing committee, which must also bear the costs. Security in the public domain, however, is a task of the government, and particularly of the police.

Police services during a World Cup come at the expense of regular police work. The opportunity costs to welfare equal the lost benefits of regular police work. To assign a monetary value to these costs, we assume that the level of police services is such that, at the margin, the costs to society for these services are equal to their benefits. The reduction in regular police services can thus be valued in terms of the hourly costs of police services. The security approach for a World Cup in the Netherlands is likely to resemble that of the World Cup in Germany. The total security costs for the 2006 World Cup are unknown, as security was arranged at state level. During the World Cup, police officers in Berlin worked a total of 230,000 hr overtime (Brenke & Wagner, 2007a). We assume that the number of hours of regular police services displaced is equal to the number of hours of overtime worked. One hour of police services costs about €100, bringing the cost of police services in Berlin to €46 million. Extrapolated to the entire World Cup, the costs amount to €491 million. The police in Hessen (Nedela, 2007) reported that the costs of providing services during the World Cup were €16 million for overtime and support. Once again equating the displacement of 1 hr of regular police services with 1 hr of overtime and extrapolating to the entire event, the costs for Germany as a whole were €427 million. The average of these two estimates seems a reasonable estimate for the security costs in the probable scenario. Corrected for inflation, this amounts to €496 million.[5] Discounted to 2010, we arrive at a figure of €153.3 million for the Netherlands. This estimate contains considerable uncertainty. We therefore assume 50% lower costs in the favorable scenario and 100% higher costs in the unfavorable scenario.

Municipalities in which the venues are located, several ministries and the police are likely to spend considerable time on preparations in the build-up to the World Cup. This effect is neither described nor estimated in the literature. Municipal officials in the Netherlands estimate that, at the start of the preparations, one Full Time Equivalent (FTE) in each city with a tournament stadium will be devoted to preparations, increasing to nearly seven FTEs in 2018. Police services during the preparations range from one FTE in 2010 to nearly five in 2018. Officials of the Dutch Ministry of the Interior estimate the services of government officials to range from 5 FTEs in 2010 to more than 15 in 2018. The concluding tasks following a World Cup require time as well. We assume one FTE to cost approximately €100,000 (including overhead).

It is also necessary to consider the operational side, including such matters as the organization of fan events, and additional sanitation and beautification of the city. In 2006, Stuttgart incurred €5 million in costs for fan events (Stadionwelt, 2006). Analogously, the costs of fan events for matches played in the Netherlands would be €30

Table 3. Total Costs of Government Services (×€ Million, excl. Security).

	NPV	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Favorable	35.8	1.0	1.1	1.3	1.5	1.8	2.1	2.8	3.6	38.5	1.0
Probable	42.7	1.0	1.1	1.3	1.5	1.8	2.1	2.8	3.6	49.8	1.0
Unfavorable	65.0	1.7	1.8	2.1	2.5	3.0	3.5	4.6	6.0	73.0	1.7

Note. The favorable scenario entails 25% lower costs than the probable scenario, the unfavorable scenario 50% higher costs. The years 2010-2017 and 2019 entail time invested by government officials (valued at €100.000 per FTE), 2018 also includes operational costs (like city-dressing). NPV = net present value.

million. Several other cost items, such as city dressing, are involved here as well. Therefore, we increase this estimate by 50% to €45 million. As with the costs involved in stadium construction, we apply a margin of uncertainty based on 25% lower costs in the favorable scenario and 50% higher costs in the unfavorable scenario. The total preparation costs and their timing are depicted in Table 3.

Other Costs

Tax exemption for FIFA. FIFA requests organizing countries to grant a tax exemption for all of its activities. The only tax income that is important for the social CBA is that which the government must forego because the World Cup is held in the Netherlands and which it would have received if that had not been the case. Therefore, taxes that the Dutch government would forego on the temporary FIFA offices, the broadcasting rights, and ticket sales are not relevant. The tax exemptions for hotel rooms rented through FIFA, however, are relevant because these rooms would have yielded tax benefits in the counterfactual without a World Cup in the Netherlands. FIFA claims 60,000 rooms for itself, the media, and sponsors. Of these rooms, 55% would be in the Netherlands. Assuming a tax percentage of 20% (value-added tax [VAT] and tourist tax) and an average room price of €100 per night, the costs of the tax exemption amount to €23.1 million. While no foregone tax income is considered in the favorable scenario, foregone taxes are estimated twice as high in the unfavorable scenario.

Investments in hotel capacity. Investments in hotel capacity are private decisions, which occur only if the benefits are at least equal to the costs. The net costs are therefore set at zero.

Hooliganism and vandalism. Football tournaments are accompanied by a risk of vandalism and hooliganism. For example, riots broke out in Charleroi surrounding the match between Germany and England during the European Championship in 2000 (Euro 2000). The probability of the occurrence of riots is small and depends ultimately on the draw. No serious disturbances have occurred during recent football tournaments. For this reason, no costs associated with hooliganism or vandalism

Table 4. Expenditures of Additional Foreign World Cup Spectators in the Netherlands.

	Unfavorable	Probable	Favorable
Total number of tickets sold	1,360,000	1,600,000	1,600,000
Number of tickets per person	3.0	2.2	1.5
Number of spectators	453,333	727,273	1,066,667
% Dutch spectators	50%	40%	35%
Number of foreign spectators	226,667	436,364	693,333
% Casuals	20%	20%	20%
% Time-switchers	25%	25%	25%
% Extenders	15%	15%	15%
% Average extension by spectators extending their stay	50%	50%	50%
Number of additional foreign spectators	107,667	207,273	329,333
Crowding-in	12.5%	12.5%	12.5%
Number of additional foreign spectators	121,125	233,182	370,500
Stay (in days) per ticket	2.0	2.0	3.0
Average duration of stay	6.0	4.4	4.5
Expenditures per day (excl. ticket and travel)	€100	€150	€200
Additional expenses (€ million)	€72.7	€153.9	€333.5
Additional expenses (€ million, discounted values)	€44.9	€95.1	€205.9

have been calculated into the favorable and probable scenario. In the unfavorable scenario, we assume that one match in the Netherlands will result in problems with material damages in the amount of €10 million, based on Dutch experience. Discounted to 2010 this is €6.2 million.

Disruptions in public life and traffic congestion. Tens of thousands of supporters need to get to and from venues and many others will attend fan events. Host cities are therefore likely to experience traffic obstruction and disruptions to normal public life (see also Matheson, 2006). We include this as a negative nonmonetized item.

Benefits of Increased Tourism

One of the most important effects of a World Cup is that tourists travel to the organizing country to attend matches. These tourists spend money on such items as lodging, transportation, food and beverages, and merchandise. Table 4 shows each step in the calculation. For the 32 matches in the Netherlands, 1.6 million tickets will be available. World Cup matches are usually (nearly) sold out. In the probable and the favorable scenarios, we assume full occupancy. In the unfavorable scenario, ticket sales are disappointing: 85% occupancy. During the 2006 World Cup, the average spectator had 2.2 tickets (Kurscheidt et al., 2008), which is utilized in the probable scenario. The unfavorable (favorable) scenario assumes an average of three (1.5) tickets per person.

During Euro 2000, on average 32% of the tickets were purchased by supporters from the organizing country (Oldenboom, Gratton, & Solberg, 2002). This percentage was somewhat higher for the Netherlands than for Belgium. During the World Cup, there would be many matches between countries far from the Netherlands. Therefore, considerably fewer foreign fans are likely to attend matches compared to European Championships. We assume a slightly higher percentage (40%) of Dutch supporters. In the favorable scenario, we assume 35%, just as during Euro 2000. In the unfavorable scenario, Dutch spectators purchase half of the tickets.

Tourists that would have come to the Netherlands even without the World Cup (casuals) contribute no additional spending and should thus not be considered, and the same applies to "time-switchers" (Preuss, Kurscheidt, & Schütte, 2007). Another group of tourists will extend their stay in the Netherlands because of the World Cup (assuming that the extension equals 50% of the total stay). One of every eight World Cup spectators brings along a companion who does not attend World Cup events (crowding-in; Helmenstein & Kleissner, 2008). All in all, additional visitors to the Netherlands are estimated to accumulate to 121,000, 233,000, and 371,000 in the respective scenarios.

Foreign visitor are likely to spend the night before and the night after a match in the Netherlands. Helmenstein, Kleissner, and Moser (2007) and Oldenboom, Gratton, and Solberg (2002) report stays of 1 or 2 nights per ticket. In the unfavorable and probable scenarios, we assume 2 nights per ticket and 3 nights per ticket in the favorable scenario. Oldenboom et al. (2002) assume an average spending of €125 per person per day. Correcting for inflation, we apply €150 in the probable scenario. In the unfavorable scenario, we assume €100 per day (e.g., if many people stay on camping sites or with friends and relatives). The arrival of many World Cup business travelers would increase the average daily spending to an assumed €200 per day in the favorable scenario.

Table 4 shows the estimated additional spending of foreign spectators. The estimated spending ranges from €72.7 million to €333.5 million.

The line of reasoning for Dutch spectators and fan-event attendees is comparable to that for foreign spectators. Only the spending of Dutch fans who would also have visited the World Cup if it were held elsewhere is a relevant benefit to Dutch welfare. For this group, avoided travel costs also represent a welfare benefit. Dutch match visitors who would not attend a World Cup match abroad account for a welfare loss. Their spending on tickets leaks out to FIFA. Because the calculations for these items are comparable to the calculations above, they are not presented here (see de Nooij, van den Berg, & Koopmans, 2010).

Crowding-out. The literature emphasizes the importance of crowding-out of regular tourists, as they expect busy and chaotic conditions, fully booked accommodations, high prices, and construction nuisance. Crowding-out was observed during the World Cup in 2002 (Matheson, 2006) and the European Championship in 2004 (Brenke & Wagner, 2007a). New York ultimately had fewer tourists than usual during the month in which it hosted the World Cup (Baade & Matheson, 2004). Maennig (2007) finds no evidence that the 2006 World Cup generated additional overnight stays in Germany, which implies a crowding-out effect of 100%. Preuss, Kurscheidt, and Schütte (2007) show that crowding-out increases with the normal popularity of a destination, to even more than 100% for Munich and Berlin. Du Plessis and Maennig (2010) show that the net increase of tourist arrivals in South Africa during the 2010 World Cup was modest with an estimated extra 40,000–90,000. In a recent empirical study, Fourie and Santana-Gallego (2011) show by means of a standard gravity model that hosting a mega-event does significantly increase tourist arrivals. However, if the event takes place in the peak season, just as the World Cup in the Netherlands in June would, the positive effect on tourist arrivals disappears completely.

Since the occupancy rate in Amsterdam is usually high, crowding-out is highly likely. A World Cup match held in the Amsterdam ArenA would attract 60,000 spectators and considerable numbers of officials and press representatives (plus additional fan-event visitors). Approximately 36,000 spectators would be foreigners. To accommodate just this group of visitors, 18,000 twin rooms are needed. In 2006, Amsterdam had 18,000 hotel rooms (Municipality of Amsterdam, 2008), with an average occupancy rate of 77%, leaving 4,000 hotel rooms available on average.

Taking these considerations, including the characteristics of the local hotel markets in other host cities, into account, the probable scenario assumes a displacement percentage of 75%. The unfavorable scenario assumes complete displacement, and the favorable scenario assumes displacement of 50%. It seems reasonable to assume that the intensity of the crowding-out is equal throughout the country. Distances in the Netherlands are so small that all venues can be reached easily from anywhere in the country. In addition to this, the hotel market in the host cities will presumably get overheated to the extent where many visitors are forced to seek lodging elsewhere. We further assume that the spending patterns of regular tourists are comparable to those of World Cup tourists. The displaced expenditures are thus estimated at €118.9 million in the unfavorable scenario, €237.8 million in the probable scenario, and €411.5 million in the favorable scenario. The displaced expenditures are highest in the favorable scenario, as it assumes many more World Cup tourists, who could scare off regular tourists.

Hosting the World Cup can enhance a country's international image and name recognition. The actual impact on the host country's image depends on many factors. Therefore, it is unclear what could be gained. Due to crowding-out, there would be less word-of-mouth advertising, as football fans are less likely to be interested in the country than "regular" tourists are. Moreover, the European Tour Operators Association (2006a, 2006b, 2008, 2009) reports that tourism grows less in cities in which mega-sports events have taken place than it does in comparable cities without such events. Therefore, the long-term effects on tourism are included as a negative nonmonetized item.

Table 5. Net Benefits of Tourism (×€ Million, Discounted Values).

	Unfavorable	Probable	Favorable
Additional spending by foreign spectators	44.9	95.1	205.9
Additional spending by foreign fan-event attendees	28.6	100.8	302.4
Crowding-out of "regular" foreign tourists	−73.4	−146.9	−254.2
Additional spending by Dutch spectators remaining at home	8.4	11.9	20.8
Additional spending by Dutch fan-event attendees remaining at home	60.5	94.9	166.0
Travel costs avoided by spectators remaining at home	2.8	3.6	4.6
Travel costs avoided by fan-event attendees remaining at home	20.2	28.7	36.9
Leakage of tickets for Dutch people who would not attend a World Cup elsewhere	−49.1	−46.2	−40.4
Long-term development of tourism due to World Cup-related image improvements	−n.m.	−n.m.	−n.m.
Net proceeds from tourism	42.7–n.m.	141.8–n.m.	442.0–n.m.

Note. n.m. = not monetized, the difference between the unfavorable, probable and favorable scenario stems from the underlying calculations and assumption made.

Total. All the costs and benefits of tourism are brought together in Table 5. The most probable scenario has a positive balance of €141.8 million, in addition to a negative nonmonetized item. The greatest benefits are derived from fan-event attendees, together amounting to approximately €195 million. The displacement of regular tourists would generate not-realized spending of €146.9 million.

Spending by FIFA, Media, and National Teams

Expenditures by the organizing committee and FIFA. Presumably, FIFA makes $400 million available to the local organizing committee (LOC) to cover such expenses as stadium rental, operations, and personnel. Stadium rental and operational costs are likely to be divided equally between the Netherlands and Belgium. The organizing committee will most likely be situated in the Netherlands. For this reason, and based on experiences with Euro 2000, 60% of the committee's expenditures are likely to be made in the Netherlands (discounted value of €105.1 million). With each World Cup, FIFA spends more (FIFA, 2007, 2008). Because the majority of this spending is already included in the LOC budget, no additional expenditures have been calculated into the probable scenario. Because of the uncertainty regarding additional expenses, the favorable (unfavorable) scenario is 50% higher (25% lower).

Lodging for national teams. Teams from the 32 participating countries would stay in the Netherlands and Belgium for some time during the preparations and the actual

Table 6. Lodging Costs for National Teams.

Number of Teams	Extending to	Number of Days	Total Days	Total Lodging Costs (×€ Million)
16	Group stage	19	304	48.5
8	Round of 16	23	184	29.3
4	Quarter-finals	27	108	17.2
2	Semi-finals	31	62	9.9
2	Final	34	68	10.8
		Total	726	115.8 whole tournament 57.9 in the Netherlands

tournament. During the 2006 World Cup in Germany, a national team spent more than €149,000 per day on lodging. For the 2008 European Championship, lodging costs for this team were €170,000 per day. We use the average of these two amounts to estimate the daily costs for a national team: €159,000.

Participating teams are required to be present at least 5 days before the tournament begins. After they have been eliminated, teams will usually stay one more night before returning home. Table 6 calculates that with these assumptions and the playing schedule of the 2006 World Cup, all national teams together would spend 726 days in the Netherlands and Belgium, representing total lodging costs of €115.8 million. Half of this amount (€57.9 million) would be spent in the Netherlands. Because teams may arrive earlier and because lodging costs are uncertain we apply an uncertainty margin of 25%.

Media lodging. During the 2008 European Championship, an estimated 12,000 media representatives were present in Austria and Switzerland (Helmenstein, Kleissner, & Moser, 2007). This translates into 750 reporters for each participating team. During a World Cup with 32 participating teams, this would imply 24,000 media reporters, half of whom (12,000) would stay in the Netherlands. Oldenboom et al. (2002) report that the large majority of the media stays until their own national team has been eliminated. Calculated similarly to lodging for national teams, reporters would stay a total of 544,500 days in the Netherlands and Belgium during the World Cup. We estimate the average daily spending at €150, €200, and €250 in the respective scenarios (these estimates are slightly higher than the average daily spending per fan). Discounted to 2010, this amounts to additional proceeds in the Netherlands of €25.2 million (unfavorable), €33.6 million (probable), and €42.0 million (favorable).

Lodging and expenditures of sponsors and partners. The lodging of sponsors and partners during the World Cup has already been figured into the regular streams of tourists and the budgets of the organizing committee and the football associations of the participating national teams. In addition, sponsors will engage in a number of activities during a World Cup. According to their own estimates, the 12 partners/ sponsors of FIFA would spend between €60 and €120 million on advertising, promotion, public relations (PR), and hospitality during the World Cup. For the Netherlands, half of the middle estimate is included (discounted to €27.8 million) in the probable scenario. Twice this amount is included in the favorable scenario, and half is included in the unfavorable scenario.

Other Benefits

Retail spending. Television sales reach a peak with each tournament. Sales of beer, snacks, and convenience foods also increase during a tournament. This does not generate a positive welfare effect if the Netherlands were to organize the World Cup, since it would also occur if the World Cup took place elsewhere. Moreover, these expenditures represent a shift in spending over time or between categories.

Economic growth. According to some reports, a major sports event can improve name recognition and reputation, thus increasing trade and thereby economic growth. The literature, however, finds no positive association (see e.g., Baade & Matheson, 2004; Siegfried & Zimbalist, 2000; Sterken, 2006). Rose and Spiegel (2011) develop a model in which bidding for a mega-event is considered to be a signal for trade liberalization intentions, which would make it an attractive option for emerging economies. They argue that the signal a country sends when bidding for a mega-event rather than the hosting itself has an effect on trade. However, for a small, open economy such as the Netherlands this hardly seems relevant.

Employment effects. No benefits related to employment are included in the analysis. Additional turnover is produced by extra employees. However, as discussed earlier, the employment effects are small and temporary (Maennig, 2007), and the additional value-added has already been counted.

Appreciation for the World Cup in the area. The joint bid for the 2018 World Cup by the Netherlands and Belgium increases the probability that the event will be in the Central-European time zone. This makes it easier to follow the World Cup on television. We include this as a positive nonmonetized item. This would be a minor effect since the 2018 World Cup was expected to be awarded to a European country anyway.

National pride, solidarity, happiness, joy, and harmony. A successful World Cup and the associated brief but global attention can generate feelings of joy, pride, and happiness among the population, as well as a reinforced sense of national identity (see e.g., Atkinson, Mourato, Szymanski, & Ozdemiroglu, 2008; Heyne, Maennig, & Süssmuth, 2007; Kavetsos & Szymanski, 2010; Ohmann, Jones, & Wilkes, 2006; Oldenboom, 2006). Kersting (2007) theoretically explores the different dimensions of national identity and pride attributed to the 2006 and 2010 World Cups. In a recent article, Kavetsos (2011) presents empirical evidence that shows that hosting Euro 2000 gave national pride in the Netherlands and Belgium a boost right after the event. However, quantification of this effect is difficult and the few estimates available vary widely. This effect has therefore been included as a positive nonmonetized item.

Effect on sports achievements. The organization of a World Cup guarantees participation and provides a home court advantage. Because of the difficulties associated with quantifying and attaching a value to these effects, they have been included as a positive nonmonetized item.

Effect on sports participation. It is often argued that a World Cup inspires people to participate in sports, thus making them healthier which marks an increase in welfare and leads to health care savings. The number of people who start exercising due to a World Cup and the accompanying health improvement are both unclear. Most proponents of this argument state that to increase sport participation additional programs are necessary. Whether the World Cup is necessary for success of these programs and the costs and the cost effectiveness associated with them is unknown. No concrete plans were known at the time the bid was submitted. The unfavorable scenario includes a negative nonmonetized item (the costs exceed the benefits). The favorable scenario includes a positive nonmonetized item. The probable scenario has an unknown sign.

Effect on the Olympic Games. A well-organized World Cup might increase the probability that the Netherlands will be elected to host the 2028 Olympic Games. Whether it is favorable to organize the Olympic Games is unclear. In the unfavorable (favorable) scenario, a negative (positive) nonmonetized item is included, while in the probable scenario an unknown sign is included.

Outcome of the Social CBA

Table 7 summarizes all costs and benefits. In the probable scenario, the expected costs of the effects that can be expressed in monetary terms exceed the benefits with €154.8 million. In the unfavorable scenario, with costs higher and benefits lower than expected, this balance is obviously even more negative: €−1.1 billion. The favorable scenario, with costs lower and benefits higher than expected, produces a positive balance of €394.7 million for effects that can be expressed in monetary terms.

Against the negative net benefits that can be expressed in monetary terms in the probable scenario stands a number of effects that are difficult to express in monetary terms. Additional benefits include the greater perceived utility of television supporters if the World Cup is played in their own time zone, a sense of national pride,

Table 7. Balance of Costs and Benefits of Holding the 2018 World Cup in the Netherlands (NPV, ×€ Million).

	Unfavorable	Probable	Favorable
Costs			
Net costs of stadium adaptations	−873.2	−279.8	−188.6
Net costs of infrastructural adaptations	−n.m.	0	0
Net costs of investments in hotel capacity	0	0	0
Costs of preparation for the government	−65.0	−42.7	−35.8
Costs of security for the government	−306.7	−153.3	−76.7
Costs related to hooligans and vandalism	−6.2	0	0
Disruptions to public life and traffic congestion	−n.m.	−n.m.	−n.m.
Total costs	−1,251.0 −n.m.	−475.8 −n.m.	−301.1 −n.m.
Benefits			
Organizing-committee costs and FIFA expenditures	78.8	105.1	157.7
Proceeds from team lodging	26.8	35.7	44.0
Proceeds from media lodging	25.2	33.6	42.0
Proceeds from lodging and additional expenditures of sponsors	13.9	27.8	55.6
Tax exemption for FIFA	0	−23.1	−46.2
Net proceeds from tourism	42.7–n.m.	141.8–n.m.	442.0–n.m.
Benefits for "television supporters"	+n.m.	+n.m.	+n.m.
National pride, solidarity, happiness, and identity	+n.m.	+n.m.	+n.m.
Effect on World Cup participation	+n.m.	+n.m.	+n.m.
Retail spending	≈0	≈0	≈0
Effect on employment opportunities	≈0	≈0	≈0
Effect on participation in sports	−n.m.	?	+n.m.
Effect on selection as host of the Olympic Games	−n.m.	?	+n.m.
Effect on trade	≈0	≈0	≈0
Total benefits	187.5 –n.m.+n.m.	321.0 –n.m.+n.m.	695.8 –n.m.+n.m.
Net benefits	−1,063.4 –n.m.+n.m.	−154.8 –n.m.+n.m.	394.7 –n.m.+n.m.
Net effect per capita (€)	−64	−9	+24

Note. n.m. = not monetized, the difference between the unfavorable, probable and favorable scenario stems from the underlying calculations and assumption made and discussed in earlier sections; FIFA = International Federation of Association Football; NPV = net present value.

harmony, and national identity, guaranteed participation of the Netherlands and the accompanying home advantage. At the same time, a number of negative effects which could not be valued might occur, like disruption of public life, traffic congestion, environmental effects, and a negative long-term effect on tourism. If the average Dutchman would be willing to pay at least €9 in the probable scenario for these nonvalued effects, the World Cup would be socially profitable.[6]

A Frame of Reference: Bidding Solo and the 2018 World Cup in Russia

To enable extrapolation of the previous CBA of the Netherlands to other cases, we present two additional calculations: we make a rough calculation of a solo-bid by the Netherlands and we compare this with the winning Russian bid.

The Netherlands Solo-Bid the 2018 World Cup

Most candidates for hosting the World Cup submit a solo-bid. This raises the question how a Dutch solo-bid would compare to the Dutch–Belgian bid. Table 8 (column 4) presents a coarse calculation of a Dutch solo-bid. The investments in stadiums would more than double. Five additional venues are needed, but the Netherlands does not have enough football clubs for which a 45,000 seat stadium is necessary. Therefore, the unprofitable part of the stadium investments would increase substantially. In addition, infrastructural projects would probably be needed surrounding these additional venues. Furthermore, the costs of security would approximately double. The costs of preparation would presumably less than double, since the host cities that would be added are on average much smaller and would host the more low-profile matches.

Spending by the LOC and FIFA in the Netherlands would increase from 60% to 100% of the budget, and the costs of FIFA's tax exemption would increase. Tourism would become a huge bottleneck. The Netherlands currently has approximately 90,000 hotel rooms, of which FIFA requires 60,000. Pressure on the Dutch hotel market would be immense and crowding-out would rise. Moreover, all the participating teams and media representatives would stay in the Netherlands, and room prices would probably rise dramatically (a substantial part of those higher prices would end up with foreign hotel owners though). Taken all tourism income together, we assume that the net benefits of tourism increase 50% compared to a duo-bid. Still, it is unlikely that additional hotel capacity will be built solely on account of the World Cup. Moreover, leakage of ticket revenues from Dutch match attendees would also rise. The net benefits from hosting the World Cup alone would less than double compared to a joint-bid.

For a Dutch solo-bid, the quantified costs would outweigh the quantified benefits by over €438.5 million. The nonvalued benefits of the World Cup should be worth

Table 8. The Russian Bid, a Dutch Solo-Bid and the Dutch–Belgian Bid (NPV, ×€ Million).

	CBA Netherlands, Joint Bid With Belgium	Change in Case of Dutch Solo-Bid	Probable Estimate Solo-Bid	CBA Russia, Compared to Dutch Solo-Bid	Probable Estimate for Russian Bid
Costs					
Net costs of stadium adaptations	−279.8	More than doubles	<−559.5	Higher	−907.8
Net costs of infrastructural adaptations	0	Probably increases	<0	Higher	−1,000.0
Net costs of investments in hotel capacity	0	Equal	0	Equal	0
Costs of preparation for the government	−42.7	50% higher	−64.1	Equal	−64.1
Costs of security for the government	−153.3	Double	−306.6	Lower	−230.0
Total costs	−475.8		<−930.2		−2,201.8
Benefits					
Organizing-committee costs and FIFA expenditures	105.1	Full expenditures	175.2	Equal	175.2
Proceeds from team lodging	35.7	50% increase	53.6	Equal	71.5
Proceeds from media lodging	33.6	50% increase	50.4	Equal	67.3
Proceeds from lodging and additional expenditures of sponsors	27.8	50% increase	41.7	Equal	55.6
Tax exemption for FIFA	−23.1	Nearly doubles	−42.0	Lower	−37.8
Additional spending by foreign visitors (spectators and fan-event attendees)	195.9	50% increase	293.8	Lower	257.4
Crowding-out of “regular” foreign tourists	−146.8	50% increase	−220.3	Equal	−193.1
Additional spending and avoided travel costs by domestic visitors (spectators and fan-event attendees)	139.1	50% increase	208.6	Lower	248.6
Leakage of tickets domestics spectators	−46.2	50% increase	−69.3	Higher	−134.3
Total benefits from tourism	141.8	50% increase	212.7	Lower	178.6
Total benefits	321.0	Higher	491.7	Lower	510.4
Net benefits	−154.8	More negative	<−438.5	More negative	−1,691.5
Net effect per capita (€)	−9		−27		−12

Note. Applied exchange rate is \$1 = €1.42. CBA = cost–benefit analysis; FIFA = International Federation of Association Football; NPV = net present value.

€27 to the average Dutchman in order to make the event socially beneficial. This seems unlikely.

The 2018 World Cup in Russia

Table 8 (column 6) presents an attempt to calculate the costs and benefits for the Russian bid. This analysis is done with less detail due to lack of data. The available budget for stadium renovation is USD 3.82 billion (FIFA, 2010). Assuming that an equal percentage of the stadium investments is profitable as in the Netherlands, the net costs are (utilizing $1 = €1.42) €907.8 million. In its bid evaluation report (FIFA, 2010), FIFA explicitly mentions the Russian infrastructure as one of the areas where substantial investments are needed to meet the standards required. Germany claims to have invested €2 billion in the infrastructure for the 2006 World Cup. The labor cost in Russia will be lower than in Germany, indicating lower costs. The explicit statement from FIFA suggests higher costs. Therefore, we estimate the Russian infrastructure cost to be equal to those in Germany (€2 billion in total). We estimate the benefits after the event at 50% of the dedicated investments (€1 billion net cost). Considering the government costs, it seems reasonable to assume the costs for preparation in Russia to be equal to those in the Netherlands, but the costs of security will probably be lower. Due to its remoteness, it is unlikely that just as many foreign fans will travel to Russia to visit matches and fan-events as would come to the Netherlands and Belgium. This will put less pressure on the authorities in terms of security; therefore we decreased these costs with 25% compared to the Netherlands.

It is unlikely that spending by FIFA and the LOC will differ compared to the Netherlands. The same holds for team and media lodging, expenditures by sponsors, and the required tax exemption.[7] In the calculations concerning the net benefits from tourism, we revised a few assumptions. First of all, from the bid evaluation report, we know that 3.1 million tickets will be available for the 2018 World Cup. With this number as a starting point, we replicated the calculations, assuming that a larger fraction (60% instead of 40%) of the tickets will be purchased by domestic spectators, because of the relative remoteness of Russia. On the other hand, foreign visitors that do still come to Russia are likely to stay longer (3 days) than they would in the Netherlands (2 days), because of sheer travel distance. Presumably, especially fan-events will be less crowded in Russia for obvious reasons. Therefore, we assume only a factor two instead of four between match attendees and fan-event attendees, and a larger fraction of domestic fan attendance. The rest of the calculations are exactly mirrored. We believe that crowding-out in Russia will be comparable to that in the Netherlands. Less foreign fans will travel to Russia, but the hotel capacity in the smaller host cities is presumably smaller and because of the vastness of the country it is not easy to find lodging outside the host cities within reasonable traveling distance. Moreover, Moscow and Saint-Petersburg are important tourist destinations, particularly in the summertime, which increases the probability of crowding-out.

Table 8 shows that the costs add up to over €2.2 billion and the net benefits to €510 million. Given the necessary assumptions, hosting the 2018 World Cup yields a net welfare loss of €1.7 billion for Russia, implying that the Russians need to be willing to pay at least €12 each for the nonvalued benefits of the event, compared to €9 in the Netherlands in case of a joint bid and €27 in case of a solo-bid.

Conclusion

The literature on costs and benefits of major sports events gives only limited guidance for a CBA of a World Cup. Some costs and benefits, such as preparation and national pride, are (almost) never taken into account. Moreover, the figures which are available are not directly transferable to other countries. However, it did prove possible to estimate the total costs and benefits, albeit with a considerable bandwidth.

The main conclusion is that the financial–economic benefits of a World Cup in the Netherlands do not stand up against the costs. However, organizing the World Cup could generate a greater sense of happiness, pride, harmony, and national identity. In the most probable estimate, if the average Dutch person would be willing to pay at least €9 for these nonvalued benefits and if the costs are limited, the World Cup would be socially profitable. Because this amount is not unreasonably high, the possibility that the World Cup could contribute to welfare cannot be ruled out. We also showed that bidding without Belgium as a cohost would most likely result in a considerably higher willingness-to-pay required to make the event socially beneficial (€27). Moreover, replicating the analysis for the winning bid shows that the quantifiable costs of hosting the World Cup will most likely outweigh the benefits for Russia. This results in a higher willingness-to-pay for the nonmonetized values (like pride) necessary of €12 to make the World Cup socially attractive.

A second conclusion is that a sober organization and good cost management are crucial to a positive result. Many uncertainties remain with regard to costs. For example, the exact investments in stadiums and infrastructure required were not known at the time of bidding.

The third conclusion is that many *ex ante* estimates of the benefits later prove much too high. One explanation for this is that, contrary to this analysis, many effects are often not considered. This study is the first to ex ante consider the costs of security and preparation borne by the government, and crowding-out of "regular" tourists. Security alone is almost equal to the negative result in the probable scenario.

The results of this social CBA where published well before the elections for the 2018 and 2022 World Cups took place. However, it is unlikely that this research negatively impacted the Dutch chances with FIFA. The Dutch government commissioned this research, and knowing the results it decided to "back the bid," because it positively evaluated the probability that the social benefits to the Netherlands would outweigh the costs. FIFA, in turn, evaluates the different bids handed in, but has different goals and interests in its decision-making process than national governments, such as striving for a smooth and well-organized tournament and maximizing its revenues. The welfare of the candidate host is not a concern of FIFA, and rightly so. However, it was also clear that FIFA was not amused by the critical public debates on the welfare impact of organizing a World Cup going on during the pre-election period in a few bidding countries, among which the Netherlands.

Finally, we argue that social CBA is a powerful tool for policy makers, which can be hugely valuable in the build-up to a bidding process for a mega-event like the World Cup to assess the real impact on domestic welfare. That is, provided that the analysis is done objectively, properly and in an early stage of the bidding process, when the opt-out possibility is still open if the balance turns out (too) negative.

Authors' Note

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Notes

1. FIFA Annual Report (2007, p. 18). Exchange rate applied: EUR 1 = CHF 1.573, with cumulative inflation of 12.6% over the period 2006-2010.
2. The bid books for the 2018 and 2022 World Cups are nearly identical. The expected costs and benefits are therefore discounted only over a longer period; this has no consequences for the sign of the outcome, only for the size of the amounts.
3. Spain/Portugal, Russia, England, Australia, Indonesia, Japan, and the United States bid to organize the World Cup in 2018 or 2022 as well. Qatar and South Korea expressed interest in hosting the 2022 World Cup. Before the World Cups of 2018 and 2022 were awarded to Qatar and Russia it was already expected that one of the two events was to be held in Europe and the other elsewhere.
4. Sensitivity analyses show that varying the discount rate has a negligible impact on the outcomes, which is intuitively straightforward, since the discounting period is relatively short.
5. This aligns nicely with the estimate of an expert from the Dutch Ministry of the Interior and a Belgian colleague: €400 to €600 million.

6. Albrecht & Laleman (2010) mirrored our analysis and estimate a willingness-to-pay required for Belgium in order to make the World Cup socially beneficial of €33 per person in the probable scenario.
7. Only adjustment with respect to the tax exemption is the applied tax rate. VAT in Russia is currently 18%.

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Applying global cost-benefit analysis methods to indoor air pollution mitigation interventions in Nepal, Kenya and Sudan: Insights and challenges

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ABSTRACT

Indoor air pollution from burning solid fuels for cooking is a major environmental health problem in developing countries, predominantly affecting children and women. Traditional household energy practices also contribute to substantial time loss and drudgery among households. While effective interventions exist, levels of investment to date have been very low, in part due to lack of evidence on economic viability. Between 2004 and 2007, different combinations of interventions – improved stoves, smoke hoods and a switch to liquefied petroleum gas – were implemented in poor communities in Nepal, Sudan and Kenya. The impacts were extensively evaluated and provided the basis for a household-level cost-benefit analysis, which essentially followed the methodology proposed by the World Health Organization. The results suggest that interventions are justified on economic grounds with estimated internal rates of return of 19%, 429% and 62% in Nepal, Kenya and Sudan, respectively. Time savings constituted by far the most important benefit followed by fuel cost savings; direct health improvements were a small component of the overall benefit. This paper describes the methodology applied, discusses the findings and highlights the methodological challenges that arise when a global approach is applied to a local programme.

1. Introduction

More than three billion people worldwide depend on solid fuels, including biomass (i.e., wood, dung and agriculture residues) and coal, to meet their basic energy needs such as cooking, boiling water and heating (WHO, 2006). These solid biomass fuels lie at the bottom of the 'energy ladder' (WHO, 2006), and their inefficient combustion releases high concentrations of hundreds of health-damaging pollutants, such as particulate matter (PM) and carbon monoxide (CO). There is abundant evidence supporting the relationship between this indoor air pollution (IAP) and a broad range of health problems, in particular childhood acute lower respiratory infections (ALRI), chronic obstructive pulmonary disease (COPD) and lung cancer (where coal is used) (Smith et al., 2004). Moreover, studies have linked IAP exposure to a variety of other health outcomes, such as low birth weight and stillbirth (Pope et al., 2010), tuberculosis (Slama et al., 2010), asthma, cataracts (Bruce et al., 2000) and high blood pressure (McCracken et al., 2007b). Based on a comparative risk assessment undertaken by the World Health Organization (WHO), IAP is responsible for 1.6 million global deaths and 2.7% of the global burden of disease annually (WHO, 2006). A majority of the population living in the poorest countries of sub-Saharan Africa and South Asia continues to rely on solid fuels, and these countries also shoulder the largest share of the health burden.

A number of technologies are available to solve the IAP problem. Switching from traditional to modern fuels, such as liquefied petroleum gas (LPG), biogas and ethanol, brings about the largest reductions in IAP. In many poor rural communities, however, access to these alternatives is limited by availability and affordability, and biomass remains the most practical fuel. Here, improved stoves – provided they are adequately designed, installed and maintained – can reduce IAP considerably. Stove location, housing construction and better ventilation are also partial remedies. All of these interventions have the potential to deliver a wide range of other benefits for poverty reduction and environmental sustainability.

Despite the critical role household energy use plays for socio-economic development and the magnitude of the health effects, in particular among women and children, the problem has been largely ignored. The reasons are likely to be manifold, including low awareness about the health impacts of IAP among the affected populations and limited availability of locally appropriate and affordable cleaner cooking technologies. One reason for the lack of international recognition is the shortage of evidence on the effectiveness and cost-effectiveness of different solutions and on

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reliable mechanisms for their delivery. Showing that improved household energy interventions can be economically efficient should contribute to stimulating investment nationally and internationally, and to widespread adoption locally.

The present study, carried out in Kenya, Sudan and Nepal, sought to understand how poor local communities could overcome the barriers that prevent them from accessing interventions to reduce IAP. A key output was to analyse the economic viability of various IAP-alleviating technologies using cost benefit analysis (CBA). We adapted the CBA guidelines developed by the WHO to a household perspective in these local settings. This report also describes the challenges that arise when global guidelines are applied and modified in the context of a specific local project, reviews methodological strengths and limitations, and compares findings with those of other CBA studies.

2. Cost-benefit analysis of household energy interventions—a review

Economic evaluation of interventions being considered for wider implementation is of growing importance as a means of demonstrating the return on investments, comparing the efficiency of one intervention against another, and helping policy-makers decide how to allocate limited budgets (WHO, 2002).

The WHO has published guidelines for CBA of household energy interventions (Hutton and Rehfuess, 2006), and has applied these in a global/regional case-study (Hutton et al., 2006). Costs and benefits were modelled under eight different intervention scenarios, covering three technical interventions – LPG, biofuel (ethanol) and a chimneyless stove based on the *rocket* design – at two levels of population coverage, 50% and 100%. The majority of reported benefit-cost ratios (BCRs) were either greater than 1 (signifying that benefits exceed costs) or had negative values that result from intervention cost savings exceeding the intervention costs, for example, where improved fuel efficiency reduces costs of purchased fuel. These analyses showed that, from a societal perspective, investments in household energy interventions can be highly cost-beneficial and, in some cases, cost-saving. Under the model assumptions, improved stoves led to the greatest overall benefit to society.

Few local or programmatic CBA studies of household energy interventions have been conducted to date. Larson and Rosen (2000) studied household demand for the control of IAP and, drawing on existing data from several developing countries, found that the theoretical willingness to pay for control measures is high and considerably exceeds costs. Habermehl (2007) examined costs and benefits for 190,000 households using *rocket* wood stoves and improved charcoal stoves, promoted by the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) in Uganda. The reported BCR of 25 suggests that every Euro invested in such interventions yields 25 Euros in return. Finally, Winrock International carried out a CBA of biogas interventions for all of sub-Saharan Africa and country-level analyses for Uganda, Rwanda and Ethiopia (Renwick et al., 2007). The intervention combined household biogas, latrine and hygiene facilities, with an approximate 30% subsidy of the biogas unit cost. This study also found favourable BCRs, ranging from 1.2 to 1.3 for the household perspective, and 4.5 to 6.8 for the societal perspective.

3. Practical action project in Kenya, Sudan and Nepal

3.1. Background

Between 2004 and 2007, Practical Action (then the Intermediate Technology Development Group or ITDG) implemented the research project 'Researching pathways to scaling up sustainable and effective kitchen smoke alleviation' among poor communities in Kenya, Sudan and Nepal (Bates et al., 2007). The project sought to set up an infrastructure for long-term delivery of smoke-alleviating interventions through development of existing social and commercial structures to promote demand, facilitate purchase through credit, and support production. The ultimate aim was for the 'beneficiary' to become the 'customer' and the role of the non-governmental organisation (NGO) to be superseded by the supplier or service provider.

This research (termed hereafter Phase II) was based on an earlier project (Phase I) (Bates et al., 2005), which identified and developed a number of low-cost and no-cost technologies for alleviating IAP in the same communities, working collaboratively with NGOs and local partners. Through focus group discussions and other participatory approaches, the project helped communities to select those interventions or combinations of interventions that they considered most appropriate to their needs and budgets, and developed a set of monitoring methods to determine their effectiveness. The monitoring in Phase I included the following components, carried out over 24 h and repeated on four occasions (twice pre-intervention and twice post-intervention):

- Room concentration of respirable particles ($PM_{3.5}$)[1].
- Kitchen CO concentrations.
- The relationship between 24 h room CO and 24 h room $PM_{3.5}$, which was derived by co-locating the pump and cyclone in approximately 30 houses in each country during each of the 4 rounds (2 pre-intervention and 2 post-intervention).

These Phase I data formed the background to the work described in the current paper.

3.2. Project location

The project (Bates et al., 2007) took place in three settings, each with distinct needs:

- Peri-urban communities in Kisumu, West Kenya, which use wood, charcoal and agricultural residues as their main cooking fuels.
- Communities near the towns of Kassala and New Halfa, Sudan, which use wood and charcoal, and struggle to find fuel due to the large influx of displaced people.
- Rural communities in Rasuwa district, a mountainous region in northern Nepal, which rely on biomass for space heating and cooking.

Details of the study communities, target populations and interventions available are provided in Table 1.

3.3. Interventions selected

Kenya: Most households in Kenya opted for LPG stove sets, comprising a 4.6 kg gas bottle and burner, or smoke hoods (Table 2). Some households also purchased low- or no-cost interventions such as solar cookers, fireless cookers and *upesi*

[1] Particulate concentrations were measured over 24 h using a Buck I.H. pump sampling at 2.2 l/min, a Higgins–Dewell cyclone and 35 mm glass-fibre filters. This produces a 50% particle cut-off at 3.5 mm. The flow rate was checked prior to each house measurement with a bubble calibrator. Filters were pre- and post-weighed in the National Metrology Centres in Nepal and Sudan, and at the University of Nairobi in Kenya (Bates, et al., 2005). The Higgins–Dewell cyclone measures the 'respirable' fraction of small particles, with most materials having an aerodynamic diameter of 3.5 μm or less. The PM concentrations measured are therefore slightly higher than those that would be found for $PM_{2.5}$ and slightly lower than those that would be found for PM_{10}.

Table 1
Overview of study communities and intervention characteristics.

	Kenya	Sudan	Nepal
Study area	Nyanza and Western Kenya provinces	Kassala and New Halfa, Eastern Sudan	Rasuwa District, Nepal
Study communities	Peri-urban and rural, mainly settled communities. The communities were selected to reflect the spectrum of geographic conditions within these provinces.	Urban and peri-urban low-income communities, including many long-term displaced communities around Kassala town. New Halfa was developed in 1960s to house a displaced Nubian community.	Mainly rural, mountain-dwelling, settled communities who require space heating as well as energy for cooking.
Total target population	63,330 around Kisumu area, but not including the central commercial districts in Kisumu town	79,000 in and around the town of Kassala	44,730 in Rasuwa district
Traditional fuels and stoves	Majority use biomass fuels, mainly wood (mix of collected and bought) and crop wastes, burned in 3-stone fires	Wood (mix of collected and bought) and charcoal, burned in 3-stone fires, and traditional charcoal stoves.	Almost exclusively wood obtained from forests, burned in traditional horseshoe shaped fire with metal tripod to support pots
Interventions available to households	Upesi stoves, rocket stoves, smoke hoods with flues venting outside, LPG sets (bottle and single burner), Eaves spaces[a], fireless cookers and solar cookers	LPG stoves: 2-burner and 3-burner; higher quality with automatic ignition; LPG *kisra sag* (hotplate)	Smoke hood and flue over the stove, venting outside; Wall insulation (with mud, straw, dung sourced locally); Tripod partly built into mud surround, with slightly raised horizontal metal bar added across front of stove to improve air ingress and combustion
Methods of payment	Women's groups managed revolving finance for other households in their immediate location. Bank accounts were opened for each of the groups.	Revolving finance organised through the Women's Development Associations that were already active through earlier Practical Action projects.	Revolving finance set up by the project team. Those wishing to access finance would form themselves into a group.
Level of subsidy	Very modest seed capital was provided by the project to each group. No ongoing subsidy was provided	Very modest seed capital was provided by the project to each group. No ongoing subsidy was provided	Very modest seed money was provided to the local groups to run revolving fund. Additionally, a subsidy of around 35% was provided to make the hoods affordable and develop the market. A district fund for IAP alleviation was established under the District Development Committee in Rasuwa to give continuity to the programme.

[a] Long narrow spaces between the top of the wall and the thatch, usually located directly above stove.

Table 2
Interventions delivered by end of project period.

Intervention	Number of households (%)	Price equivalent (US$)	Estimated product life	Comments
Kenya				
Upesi stove[a]	160 (100%)	3	1–2 years	
Cladded *upesi* stove[a]		9		
Smoke hood	7 (4%)	71	10 years	Estimate based on no reports of failures, up to the present time
LPG cooker	64 (40%)	53	5–10 years	Gas bottles used on exchange basis. Hotplate $<$\$10
Portable fireless cooker (insulated baskets)	Data not collected	15	2–3 years	Estimate
Built-in fireless cooker	Data not collected	3	Kitchen lifetime	
CookKits (low-cost solar cookstoves)	Data not collected	8	0.5 years	Estimate
Eaves spaces	32 (20%)	<5	Kitchen lifetime	Made by householder or local artisan
Mean cost of interventions for project households		38		
Kenya-total	160 (100%)			
Nepal				
Smoke hood	600 (100%)	68	10 years	Estimate based on no reports of failures, up to the present time
Sudan				
LPG stove+gas bottle+some households with kisra sag	120 (78%)	71	10 years	Estimate
LPG stove+*kisra sag*	33 (22%)	71	10 years	Estimate
Sudan-total	153 (100%)			

[a] Ceramic stoves without flue, designed to improve combustion and reduce fuel consumption. Any households without upesi stoves received and paid for these themselves by the end of the project.

stoves. The mean price reflects the totals spent on two major items—LPG stoves or smoke hoods. Low-cost items were sourced locally by private agreements between households.

Sudan: LPG was the only intervention selected in Sudan (Table 2). Some households also opted for a gas-powered *kisra sag*—a hotplate for making *kisra*, which is the main local staple food. The price reflects the mean value paid by all study households. In practice, due to an interrupted LPG supply during study follow-up, many homes reverted to using charcoal during this period (see Section 5.2.1).

Nepal: The main intervention chosen was a smoke hood, supplemented by wall insulation and modification to the traditional tripod stove to improve air flow. Wall insulation and stove improvements were made at no cost by household members or neighbours (Table 2).

4. Methods

4.1. Data collection

4.1.1. Sample selection and survey methods

A before-and-after design was used to study intervention impacts, comparing baseline data with that obtained after 8–12 months follow-up (Table 3). An intermediate survey of women's perceptions and priorities was also conducted.

Between 160 and 200 homes were recruited from each country community for the survey and IAP measurements (Table 4). The sampling strategy was designed to provide a representative sample of homes that were planning to purchase interventions. These households can be considered 'early adopters', as the programme was at a relatively early stage of development. The reasons for the relatively low numbers of households available for follow-up in Sudan and Kenya are migration and slower than expected adoption, respectively.

Survey questionnaires (baseline, follow-up) were administered by trained interviewers and are available at http://www.hedon.info/HouseholdSmokeMonitoring. The questionnaire comprised sections on the home (e.g. number of rooms, construction materials), socio-demographic information, household energy use (e.g. fuel collection and purchase, cooking time) and health. The health questionnaire focused on the woman respondent and the youngest child, covering respiratory symptoms, headache, eye irritation, burns and scalds. Questions on chronic respiratory symptoms were based on established validated questionnaires (Medical Research Council/IUATLD), and for child ALRI on Demographic and Health Survey questionnaires (OrcMacro, 2010). Questions on health were included to assess prevalence of, and impact on, adult respiratory symptoms, monitor intervention safety in relation to burns and scalds and facilitate engagement with the communities on links between IAP and health. These health data do not, however, provide direct outcome measures to be used in the CBA.

Following questionnaire administration, women's lung function and breath CO were measured. Monitors to measure 24 h kitchen CO concentrations were installed on the same day and collected the following day, using the same methods as in Phase I (Bates et al., 2005). A brief description of all data collection procedures is given here for completeness, although not all were utilised in the CBA. Other results, in particular on women's respiratory symptoms and lung function, will be reported separately.

Women's lung function was measured using a Micromedical Micro spirometer (Micromedical Ltd, Rochester Kent, UK). The American Thoracic Society protocol was followed (American Thoracic Society, 1995), with field staff carefully trained using a Microloop spirometer illustrating flow-volume curves. Breath CO was measured three times in succession using a Micro CO device (Micromedical Ltd, Rochester Kent, UK). Kitchen CO concentrations were measured using a T82 single gas CO monitor (Industrial Scientific Corp, model 810-4133-ABCD) in a standardized placement (1.5 m from stove, 1.5 m above floor level, and away from windows and doors, or as close to this location as feasible). The T82 monitor was run continuously for 24 h per household, recording successive 3 min-intervals. Calibration of the T82 monitor was carried out prior to, and after the study using a standardized 100 ppm span gas. Lithium batteries were required in the colder temperatures of Nepal.

The intermediate survey was conducted at varying intervals after the interventions had been installed with seven, six and four groups in Kenya, Nepal and Sudan, respectively; also, 30 individuals in each country were interviewed separately. The purpose of the intermediate survey was to identify those impacts deemed important by the project communities, with the insights used to formulate questions on women's perceptions of the technologies in the final follow-up survey.

An MS Access database was used for data management, with data being entered and subsequently read aloud by one researcher whilst the other checked data on screen. Analysis was carried out using SPSS version 11.5 (Nepal) and 13.0 (UK) (http://www.spss.com). The study received ethical approval from the University of Liverpool, and informed consent was obtained prior to the baseline survey.

4.2. CBA framework

We conducted CBA, considering all costs and benefits from a household perspective. This can provide insight into how households value the intervention, which aspects of the intervention drive adoption patterns and how many households might be willing to pay.

Table 4
Follow-up numbers for survey and monitoring.

	Respondents (% of baseline)		
Respondents at baseline	**Kenya (160)**	**Sudan (200)**	**Nepal (192)**
Survey questionnaire	126 (79)	146 (73)	192 (100)
Lung function	112 (70)	146 (73)	192 (100)
CO kitchen	59 (37)	50 (25)	124 (65)
CO breath	112 (70)	146 (73)	126 (66)

Table 3
Overview of data collection in before-and-after comparison.

	Baseline survey and monitoring (before)	Intermediate survey	Follow-up survey and monitoring (after)
Kenya	December'05–June'06	October'06–November'06	January'07–July'07
Sudan	September'05–December'05	August'06	April'07–May'07
Nepal	December'05–July'06	October'06–December'06	January'07–February'08
Data collection elements	Survey questionnaire; women's lung function; women's breath CO; 24 hour CO kitchen concentrations	Group survey	Revised survey questionnaire; women's lung function; women's breath CO; 24 h CO kitchen concentration

4.2.1. Study populations

The populations for whom the CBA was conducted relate directly to the areas in which the development work was carried out—that is, poor, mainly biomass-dependent households in the programme areas. Health benefits were calculated for the specific age and sex groups to which evidence on risks relate, rather than the total population. The population numbers providing the basis for different benefits under the CBA are given in Table 5.

4.2.2. Concepts and assumptions

Time horizon: The duration of the intervention is assumed to be 10 years, so benefits and costs for obtaining and maintaining the intervention were determined for this period.

Coverage: We observed intervention coverage during the first year as 2.3%, 5.2% and 9.3% of the target populations in Kenya, Nepal and Sudan, respectively. In all the three countries, coverage was assumed to increase linearly from year-1 to 25% by year-10.

Discounting: All costs and benefits are discounted at 10% per year. Although high for a societal analysis, this is considered appropriate for a household perspective analysis.

Benefit-cost ratio (*BCR*): The BCR assesses the overall benefit of the intervention, valued in monetary terms, per currency unit spent. This represents the factor by which economic benefits exceed economic costs.

Net present value (*NPV*): The net present value shows the net monetary or economic gain that can be expected from the intervention in currency units.

Internal rate of return (*IRR*): The internal rate of return is the discount rate at which the future expected stream of benefits equals the future expected stream of costs. It represents the discount rate required to obtain a zero net present value. This is particularly useful where there is uncertainty about the most appropriate discount rate to apply.

4.2.3. Costs and benefits included

We distinguish between intervention investment costs (and replacement costs, where product life is shorter than the ten-year time horizon used) and recurrent costs of the intervention. Investment costs comprise the cost of a new technology (e.g. stove and smoke hood) with installation. Recurrent costs comprise all operation, repair and maintenance costs related to the intervention.

We consider three types of economic benefits: health benefits, fuel savings and cooking time savings. Health benefits result in direct monetary savings as a consequence of reduced treatment costs and in time savings due to fewer days spent ill or having to care for a sick child. Fuel savings include direct monetary savings, where fuel is purchased at baseline or time savings, where fuel is collected at baseline. Any time savings – as a result of less time spent ill, collecting fuel or cooking – could, in principle, be used more productively.

Table 5
Population considered in CBA.

Age/sex group	Kenya (% of population in programme area)	Sudan (% of population in programme area)	Nepal (% of population in programme area)
Children < 5 years	9297 (14.7)	11,248 (14.8)	5214 (14.8)
Males 30 years and over	7922 (12.5)	12,160 (16.0)	7246 (16.2)
Females 30 years and over	8657 (13.7)	12,563 (16.5)	7291 (16.3)
Population in programme area	63,330 (100.0)	79,000 (100.0)	44,730 (100.0)

4.3. Assessment of costs

The initial capital investment for a household is the sum of the intervention market price and the installation cost. This is the actual cost incurred by households and any subsidy, where applicable. For LPG, this includes the cost of the stove, gas bottle and associated equipment (connection and pipe). All cost data were obtained directly from the country projects. Estimates of product life (Table 2) suggested that the capital investment would be required only once over the ten-year intervention period for all three countries.

Fuel costs were obtained from the surveys; any reductions in fuel costs were valued under benefits. The anticipated costs of maintaining and repairing interventions to ensure effective functioning during each of the ten years were obtained from the level of repair and maintenance reported in the survey, although it is recognised that this may not capture all of the maintenance requirements over the full time horizon.

4.4. Assessment of benefits

4.4.1. Health benefits

Health benefits were assessed for ALRI among children under 5 and COPD among adults aged 30 years and above, consistent with the evidence used in WHO's comparative risk assessment (Smith et al., 2004). As none of the households use coal, lung cancer was excluded; evidence for other outcomes was considered too tentative (Smith et al., 2004).

Post-intervention improvements in child ALRI and COPD could not be directly measured given the resources and timescale of the study. Instead, we used a proxy for personal exposure to estimate the impact on these two diseases. The measure of personal exposure used in the study (breath CO) is relatively novel and less well-understood. Therefore, changes in exposure for the purposes of this study are based on changes in 24 hour kitchen CO data, as follows. Phase I provided data, from each home, on kitchen CO and women's personal CO over the same period. In each study setting this was used to describe the relationship between changes in kitchen CO following the Phase I interventions and the consequent changes in women's personal CO exposure (Bates et al., 2005). It was assumed that levels of exposure and changes in exposure are the same for women, children under 5 years and men. The following methods were used to estimate the impacts of the exposure reductions on the number of cases of ALRI and COPD.

4.4.1.1. Averted cases of ALRI in children under 5 years. Due to uncertainties in the exposure–response relationship between CO exposure and ALRI, two approaches were used to estimate intervention impact:

- We used preliminary data from the RESPIRE trial of the relationship between reductions in child exposure (48 h average CO) and incidence of clinically diagnosed pneumonia) (McCracken et al., 2007a). We derived an estimate of the reduction in ALRI risk by relating the RESPIRE exposure–response function to the exposure levels measured in the current study.
- Following the method described by Desai and colleagues (Desai et al., 2004; WHO, 2002), we applied relative risks for solid fuel users compared to non-solid fuel users and a ventilation coefficient derived from the percentage exposure reduction in each study area.

Table 6
Estimated rates and cases of ALRI and COPD averted during the first and final year of intervention.

Countries	Year 1				Year 10			
	% intervention coverage	Averted ALRI cases		COPD cases averted	% intervention coverage	Averted ALRI cases		COPD cases averted
		RESPIRE	Desai	Desai		RESPIRE	Desai	Desai
Kenya	2.3	21	12	0.07	25.0	232	149	0.83
Sudan	9.3	51	30	0.22	25.0	138	85	0.62
Nepal	5.2	65	27	0.20	25.0	314	145	1.11

Estimated incidence rates for ALRI: episodes per child/year

Kenya: 0.32	Sudan: 0.29	Nepal: 0.50

Estimated incidence rates for COPD (new cases per 1000 per year)

Kenya:	Males 1.52	Females 0.64
Sudan:	Males 1.42	Females 0.59
Nepal:	Males 1.58	Females 1.36

Both approaches required estimates of ALRI incidence in each area, obtained from a recent review of pneumonia incidence in developing countries, which includes two studies from Nepal and one from Kenya (Rudan et al., 2004), and the national data from WHO (WHO, 2010) (Table 6). Ultimately, estimates from Rudan et al. (2004) were used for all countries, as the WHO estimates for Sudan were extremely low and did not appear consistent with the level of poverty prevalent among the displaced person communities concerned.

4.4.1.2. Averted cases of COPD in women and men over 30 years. Data on COPD incidence among women and men over 30 years of age were obtained from WHO (WHO, 2010). These incidence rates appear very low (Table 6), particularly for women, but were considered the best available. Averted cases were calculated using the method of Desai et al. (2004), as described above for ALRI.

For COPD, averted cases over the 10 years are in effect delayed cases, as it would take around 20 years to prevent the occurrence of new cases. Thus, reduced exposure for a period of 10 years is assumed to have the effect of delaying onset of disease for 10 years in individuals at risk.

4.4.1.3. Cost savings from cases averted. Calculation of cost savings resulting from prevented cases takes a similar approach for both ALRI and COPD. Using data from the WHO CBA (Hutton et al., 2006), consideration is given to the distribution of disease severity, anticipated uptake of modern healthcare, duration of illness and cost of care received at health facilities. Data for the relevant WHO epidemiological sub-region were used: EMR-D for Sudan, AFR-E for Kenya and SEAR-D for Nepal.

Time savings resulting from less illness are valued using Gross National Income (GNI) per capita, with illness duration varying by disease severity and whether or not treated (Hutton et al., 2006). Time lost caring for sick children with ALRI (illness duration in days) is valued at 50% of the daily GNI per capita. For time lost with COPD, 100% of the daily GNI per capita is applied.

4.4.2. Fuel savings

Information on fuel purchased or gathered per week was obtained from the survey. Annual firewood savings due to the intervention were calculated by comparing annual firewood use in pre-intervention and post-intervention households. Savings on fuel expenditure were monetized by applying costs per kg of fuel, obtained from country projects. Information on weekly fuel collection was obtained from the survey, with changes valued using GNI per capita.

4.4.3. Cooking time savings

For homes using biomass fuels, cooking time was estimated from the duration of time that kitchen CO exceeded 9 ppm, as measured by the T82 monitor. For post-intervention homes using LPG, cooking time was assumed to correspond to the maximum time for which LPG stoves were used per day. Based on the time between gas bottle refills this was estimated conservatively to be 1 h per day, which was consistent with reported time savings. Cooking time savings were calculated by taking the mean of all individual household differences between time spent at baseline and time spent at follow-up, and monetized using GNI per capita.

5. Results

5.1. Quantification and distribution of costs

In Nepal, the capital cost of a smoke hood was US$68.00 with an estimated annual maintenance requirement of US$1.5. The type of fuel, namely wood, did not change with the intervention, and consequently, there were no changes in fuel costs; observed fuel savings were assessed and valued under benefits.

In Sudan, the initial investment to purchase a LPG set was US$71.0 and the annual refilling cost was estimated at US$58.5 per household. Prior to intervention most homes purchased most of their wood and/or charcoal; direct monetary savings due to reduced biomass fuel consumption were included under benefits.

In Kenya, the average investment cost per household, based on the adoption of LPG stove sets or smoke hoods, was estimated at US$38.5 with an annual fuel cost of US$20.0. Time savings from reduced firewood collection were included under benefits.

5.2. Quantification and distribution of benefits

5.2.1. Health benefits

High concentrations of CO were found in pre-intervention households in all three communities. Post-intervention, there were highly significant reductions in kitchen 24 h CO concentrations, 72% in Kenya and 88% in Nepal (Table 7). Based on the relationships between changes in kitchen CO and changes in personal exposure studied in Phase I, these room CO reductions

Table 7
Changes in average 24 h room CO concentrations (ppm).

Measure	Smoking		N	Pre-intervention	Post-intervention	Difference	SE	95% CI	p-value[a]
Kenya									
Mean			58	9.05	2.55	6.50	1.34	3.81, 9.19	< 0.001
Median			58	2.28	1.44	0.84	0.41	0.02, 1.65	0.045
Sudan									
Mean	Non-smoker		85	4.54	4.64	−0.10	0.36	−0.82, 0.63	0.791
	Smoker		7	5.07	5.77	−0.70	1.76	−5.01, 3.60	0.703
Median	Non-smoker		85	2.36	2.55	−0.20	0.15	−0.49, 0.12	0.225
	Smoker		7	2.57	3.00	−0.42	0.61	−1.93, 1.07	0.510
Nepal									
Change in **mean** room CO		Ex/never	65	13.20	1.60	11.50	2.36	6.80, 16.30	< 0.001
		Current < 10/day	34	11.60	1.60	9.90	1.24	7.50, 12.50	< 0.001
		Current 10+/day	25	13.60	1.30	12.30	5.50	1.00, 23.60	0.034
		All	124	12.80	1.60	11.30	1.68	7.90, 14.60	< 0.001
Change in **median** room CO		Ex/never	65	5.30	0.23	5.06	0.99	3.08, 7.05	< 0.001
		Current < 10/day	34	5.69	0.21	5.48	0.76	3.94, 7.03	< 0.001
		Current 10+/day	25	6.28	0.04	6.24	2.59	0.90, 11.58	0.024
		All	124	5.60	0.20	5.40	0.76	3.90, 6.90	< 0.001

SE: Standard error of the mean difference between R1 and R3.
Paired *t*-test used as the differences between means (and average of room median values) are not markedly skewed.

[a] *T*-test. Results for Wilcoxon paired test are (i) < 0.0005 for room mean, and (ii) 0.032 for room median.

Table 8
Net incremental benefits per year (natural units per household).

Health Benefits		Kenya	Sudan	Nepal
Avoided ALRI healthcare costs	US$	0.028	0.410	0.072
Avoided COPD healthcare costs	US$	0.002	0.000	0.008
Time savings due to avoided ALRI cases	Hours	2.88	1.68	6.72
Time savings due to avoided COPD cases	Hours	0.24	0.00	0.24
Fuel savings				
Fuel costs (where purchased)	US$	20.02	46.20	0
Fuel collection time (where collected)	Hours	64	0	152
Cooking time savings	Hours	961	119	83

were estimated to lead to personal exposure reductions of 65% in Kenya, and 80% in Nepal.

In Sudan, post-intervention CO concentrations were slightly increased. This occurred because of supply problems with LPG, which led households to fall back extensively on charcoal (Table 7). Compared with wood, charcoal produces high levels of CO but considerably less PM. With charcoal-using households excluded, there was a post-intervention reduction of approximately 10%. In order to estimate the actual reduction in PM between pre-intervention biomass use to post-intervention mixed LPG and charcoal use, an adjustment was made for predominantly charcoal-using homes based on the ratios of PM:CO for wood and for charcoal (Aprovecho Research Centre, personal communication), which indicated that charcoal emits 20–30% of the measured PM for the equivalent concentration of CO. This led to an estimated reduction in personal exposure of 40%.

Using the RESPIRE exposure–response function, 21, 65 and 51 ALRI cases were averted during the first year of intervention in Kenya, Nepal and Sudan, respectively. (Table 6) Over 10 years, these figures rose with projected coverage reaching 25% to 232, 314 and 138 cases, respectively, in the final year. The calculations based on the Desai method yielded figures around 50% of those based on the RESPIRE method. To derive healthcare savings and time savings from averted ALRI cases, we used the RESPIRE method. The estimated number of COPD cases averted was very low, essentially due to a very low reported incidence (Table 6).

Following the WHO CBA approach, we assumed that 56%, 59% and 62% of ALRI cases were seeking care in Kenya, Sudan and Nepal, respectively; 30% of those affected by COPD were assumed to seek and receive care. For both diseases, healthcare cost savings per household and year are limited (Table 8). Overall, per household per year, avoided healthcare costs for both diseases amount to US$0.03, US$0.41 and US$0.08 in Kenya, Sudan and Nepal, respectively. Time savings as a result of less time spent looking after a child affected by ALRI were estimated at 2.88, 1.68 and 6.72 h per household in Kenya, Sudan and Nepal, respectively; time savings for COPD are much lower (Table 8).

Monetizing all health-related benefits during the first year, averted ALRI cases resulted in benefits of US$85, US$212 and US$255 for project beneficiaries in Kenya, Sudan and Nepal, respectively; for COPD, the respective figures were US$8, US$17 and US$23. Over the ten-year intervention period, health-related benefits as a result of averted ALRI amounted to US$945, US$574 and US$1235 in Kenya, Sudan and Nepal, respectively; for COPD they were US$95, US$47 and US$130, respectively.

5.2.2. Fuel savings

In Kenya, the intervention resulted in net savings of 64 h per year in fuel collection time for households collecting firewood, and of US$20 in fuel costs for households purchasing firewood (Table 8). In Sudan, reduced fuel costs of US$46 per household were observed. In Nepal, annual fuel savings of 712 kg per household resulted in 152 fewer hours spent on firewood collection.

5.2.3. Cooking time savings

Many households in Kenya switched to LPG to cook quick foods, such as brewing tea, leading to cooking time savings of 961 h per household (Table 8). Likewise, substantial cooking time savings of 119 h per household were obtained in Sudan; in Nepal, they were more limited at 83 h per household. When these cooking time savings are valued using GNI per capita, they amount to US$137, US$16 and US$6 per year in Kenya, Sudan and Nepal, respectively (Table 9).

5.2.4. Distribution of benefits

In Kenya, cooking time savings are by far the largest contributor to overall benefit, although fuel savings due to direct monetary savings and less time spent collecting fuel are also important (Table 9). In Sudan and Nepal, benefits are equally dominated by fuel savings and cooking time savings. Interestingly, in all three countries the direct health benefits constitute a small component of overall benefit.

5.3. Benefit-cost ratio and internal rate of return

Overall, these results indicate that investments in IAP-alleviating interventions can be cost-beneficial and, in some cases, highly cost-beneficial (Table 10).

In Nepal, a BCR of 1.4 indicates that the costs and benefits of smoke hoods in this particular community are roughly equal. A BCR of 21.4 in Kenya suggests that every US$ invested may result in more than US$20 in benefit. With a BCR of 2.5 in Sudan intervention benefits outweigh intervention costs by a factor of more than 2.

Positive net present values in all three countries also suggest economic efficiency. Internal rates of return of 19%, 429% and 62%, respectively, in Nepal, Kenya and Sudan all clearly exceed the discount rate of 10%.

Table 9
Net incremental costs and benefits over ten-year intervention period (US$ per household).

	Kenya	Sudan	Nepal
Cost			
Investment cost (total)	38.50	80.08	70.84
Maintenance cost (annual)	1.54	12.32	1.54
Health benefits			
Healthcare cost savings (annual)	0.03	0.41	0.08
Health-related time savings (annual)	0.10	0.29	0.23
Fuel savings			
Fuel cost savings (annual)	20.64	46.20	0.00
Fuel collection time savings (annual)	9.12	0.45	11.27
Cooking time savings (annual)	136.86	15.92	6.14

Table 10
Household-perspective cost benefit analysis over ten-year intervention period (US$ per household).

	Present value (US$)		Net present value at 10% discount rate (US$)	IRR (%)	BCR at 10% discount rate
	Cost	Benefit			
Nepal	80.3	109.9	29.6	19.0	1.4
Kenya	48.0	1025.0	977.0	429.3	21.4
Sudan	155.8	382.4	226.7	61.8	2.5

6. Discussion

Economic evaluation studies of interventions with complex, multiple impacts in resource-poor settings are inevitably subject to limitations. In the following, we consider the challenges we encountered and discuss limitations and strengths of the current study. In conducting CBA we tried to follow the WHO guidance which did, however, require several adaptations. We therefore evaluate our methodological approach and its consequences relative to the approach originally proposed by the WHO. Finally, we compare our results with those of the WHO CBA and the few other setting-specific CBA studies published to date.

6.1. Challenges of conducting 'real-life' CBA

One of the strengths of this study is that it was conducted in a 'real-life' setting, among households that had decided for themselves to purchase interventions. While these households are all from resource-poor communities, they do represent samples of 'early adopters'. Promoting adoption among 'later adopters' is likely to be associated with programmatic challenges, but the balance of costs and benefits is expected to be similar from a household perspective.

In a controlled research setting, intervention recipients and their characteristics are clearly defined, and so are the points in time when the intervention is received and when follow-up occurs. A major difficulty with conducting CBA as part of a community programme that attempts to achieve sustainable intervention uptake over time is the selection of a representative sample, especially as this selection should not interfere with the development process. Bias may result from respondents providing favourable answers to the field teams that are known to be part of the project responsible for intervention development, promotion, availability and finance. In our study, this effect is mitigated by households themselves paying for all or a majority of intervention costs. Bias in IAP measurements, designed to provide an objective assessment of pollution levels before and after the interventions, is considered unlikely. We believe that making compromises in sample selection, sample sizes and blinding is, at least to some extent, justified by the resultant findings giving a more realistic idea of costs and benefits in an evolving, sustainable programme.

Two specific problems led to reduced numbers of households monitored at follow-up. In Sudan, the signing of a peace treaty led to many households returning to their original homes. In Kenya, many households that had agreed to purchase LPG sets or smoke hoods were unable to make the down-payment during the project period. Consequently, although baseline monitoring had been conducted, there were not enough households with interventions to be monitored at follow-up. In the context of an evolving community development programme, where households themselves pay for the intervention, it was considered unethical to put pressure on households (Owalla, 2007).

A further strength of this study is that a majority of the data were directly obtained from participating households. Rather than treating economic analysis as an afterthought, survey instruments were designed to collect the required information. Where assumptions needed to be made these could be cross-validated against survey results (e.g. cooking time assumptions in Sudan) or interpreted with caution in view of familiarity with local circumstances (e.g. COPD incidence in all three settings).

Although much of the calculation of costs and benefits was based on empirical data from the surveys and project records, this was only partially the case for health outcomes. The assessment of intervention impact on ALRI among children would have required considerably larger numbers of households, and for COPD a much extended timescale, both of which have major implications for resources. These are important practical issues to consider in designing future CBA studies. Further assessment of the indirect methods based on changes in IAP concentrations and exposure, as used here, would be valuable. The assessment of health impacts was also limited by uncertainty about incidence rates, particularly for COPD, and the very low level of care seeking for prevalent, symptomatic cases. It would be useful, and informative, to study cost savings if care seeking and provision were at optimal levels.

In valuing benefits such as time savings, which make up the greatest share of overall benefit, we followed the human capital approach (Hutton and Rehfuess, 2006). In doing so, we could not attribute any formal benefit to the value that households place on other improvements in their lives, such as general health and cleanliness. Future studies could explore contingent valuation for such issues. For example, kitchens with LPG stoves or smoke hoods were found in much better condition than those with traditional biomass stoves, and many women reported that maintaining the house, clothes and pots in good order requires far less drudgery.

6.2. Adapting the WHO methodological approach to a project-level CBA

6.2.1. CBA perspective

WHO conducted a CBA for eleven so-called epidemiological subregions, defined according to their location in six world regions (e.g. sub-Saharan Africa) and levels of child and adult mortality (e.g. very high adult and high child mortality). These covered all developing and middle-income countries in Latin America, Asia, Africa and the Middle East. The only distinction made subnationally was between urban and rural settings. The goal of the study was to provide guidance to policy-makers as to whether household energy interventions, in principle, represent a worthwhile investment of national funding or international development aid. The study was undertaken from a societal perspective, i.e. considering all costs (and savings) and benefits (or drawbacks) brought about by the intervention, independent of whether these occur at the household, community or national level and of which stakeholders or sectors are affected.

As discussed below, the WHO CBA predominantly drew on global- and national-level data sources; it did not take local or cultural needs of specific countries or subpopulations into account. Given the highly generalised nature of the analysis, the results apply at the level of groups of countries and provide global insights into the economics of household energy interventions; they cannot usually be extrapolated to individual countries and certainly cannot be taken to apply to specific settings within countries.

In contrast, the present CBA was conducted in three local settings that differ much in relation to world regions (e.g. South East Asia versus sub-Saharan Africa), specific geographical setting and related household energy needs (e.g. rural, mountainous Rasuwa district in Nepal versus urban and peri-urban Kassala in Sudan), and income levels (Table 1). Our goal was to examine economic efficiency from the perspective of affected households. Any positive or negative consequences of the intervention to the healthcare system (e.g. healthcare savings among healthcare providers), the local environment (e.g. less trees being felled due to firewood savings) and the global environment (e.g. reduced greenhouse gas emissions due to more efficient and cleaner fuel combustion) were not considered. Unlike the WHO study we also did not estimate the impact of interventions on the number of ALRI and COPD deaths averted due to small sample sizes. On the one hand, we provided households themselves with insights as to whether changing cooking technologies and habits can be a worthwhile investment. On the other hand, we generated information for Practical Action as the implementing agency and the UK Department for International Development as the funding agency as to whether their efforts make a difference to the lives of poor communities in the developing world.

Our findings are based on very specific local circumstances; they may be extrapolated to settings with similar geographical and population characteristics in the same country or world region but certainly cannot be widely generalised. In addition to random error, the large differences observed in results between the three settings are a logical consequence of local circumstances, such as different interventions suiting household needs and different prices paid. They reinforce that highly generalised findings, such as those of the WHO CBA, should not be taken to apply to specific settings.

6.2.2. Selection of interventions and populations

The CBA undertaken by WHO modelled different approaches towards achieving the voluntary Millennium Development Goal target to halve, by 2015, the proportion of the population relying on traditional household energy (i.e. 50% coverage), as well as a 100% coverage scenario. It selected three interventions – LPG stoves, ethanol stoves and an improved *rocket*-type biomass stove – as these are currently available on several continents, showing potential for scale-up. It examined one intervention at a time, i.e. it did not consider the mixed or joint implementation of cleaner fuel- and improved stove interventions. Given the purpose of the global study this approach may be appropriate. It is, however, far removed from reality as 'one size fits all' solutions to the household energy problem do not exist, and the assumption of 100% coverage with a single intervention appears highly questionable.

In the present study focus group discussions were conducted with women to select a subset of interventions that best suited their cooking and/or heating needs and budget from a broader range of interventions collated by Practical Action. During the implementation phase, individual households in the target area decided whether and when to purchase an intervention, and chose their intervention among the subset of interventions available. As a result, different interventions were implemented alone or in combination and our CBA was conducted for a population of 'early adopters' among a much larger target population.

6.2.3. Assessment and valuation of costs and benefits

Following the WHO guidance, we distinguished between investment and operational costs. Rather than using figures and assumptions applicable at national level, we sourced local prices of technologies and fuel and survey-based information on fuel use, fuel purchase and fuel collection prior to the intervention.

Differences in the assessment of benefits are more marked. The WHO study assumed ideal installation, performance (including user behaviour) and maintenance of the intervention over the course of the ten-year period under consideration. This assumption is not likely to be realistic and the global CBA results may thus indicate a maximum rather than an average. In contrast, our analysis was based on the measured costs and benefits as they occurred over the course of the first year following intervention installation. Costs and benefits were assumed to apply during the full ten-year intervention period, which – due to increase in maintenance requirements, possible changes in user behaviour over time and uncertainties in product life – may still overestimate benefits relative to costs.

In estimating health benefits, the measurement of CO concentrations represents an important strength of our study. The WHO CBA identified three published studies of changes in personal exposure to CO in homes with improved stoves relative to open fires (Bruce et al., 2002, 2004; Naeher et al., 2000), derived an average reduction in personal exposure of 35% and applied this average to the non-chimney *rocket* stove intervention modelled. For the LPG intervention, the WHO CBA assumed that all IAP-attributable cases of ALRI and COPD would be avoided. In contrast, we used measured changes in kitchen CO levels and empirical data from Phase I to estimate reductions in personal exposure. The averages derived for our CBA thus directly apply to the households under study. Which of the two approaches for estimating reductions in ALRI – RESPIRE exposure–response function or Desai et al. (2004) – provides the more accurate results remains to be judged but, importantly, both methods indicate clear health benefits. As health benefits constitute a relatively small proportion of the overall benefits, using one approach versus the other makes only limited differences to conclusions about economic efficiency.

Overall, we believe that the current study is both more accurate and realistic in its assessment of costs and benefits of household energy interventions than the WHO study as almost all inputs are based on data collected among the population of interest. The findings are also more conservative due to fewer benefits being included and a discount rate of 10% rather than 3% being applied. On the negative side, small sample sizes lead to large uncertainties around our estimates.

6.3. Comparison with other CBA studies

6.3.1. Benefit cost ratio

While the results of household perspective CBAs and societal CBAs are not directly comparable, some important similarities emerge and are discussed here.

LPG: For 50% coverage with LPG, the WHO CBA finds a global BCR of 22.3 in urban settings and a BCR of 3.2 in rural settings (WHO, 2006). LPG interventions show a greater economic return in urban areas, probably because most households are constrained to purchase rather than collect their biomass fuels. In Emr-D (Eastern Mediterranean Region, high child and high adult mortality), where Sudan is located, the BCR in the urban setting is negative, indicating that the intervention is cost-saving purely on the grounds of fuel cost savings, whereas the BCR in the rural setting is 2.2. In this light, our household BCR of 2.5 for an LPG intervention in a peri-urban population in Sudan makes sense; a societal BCR in the same setting is likely to show a much larger return on investment.

Smoke hoods: Smoke hoods were not evaluated in the global study but constitute the primary intervention implemented in our study in Nepal. With a BCR of 1.4, benefits and costs of the intervention are roughly equal from a household perspective. For improved stoves, the WHO CBA shows negative BCRs both globally and in the more directly relevant urban and rural settings in Sear-D (South East Asia region, high child and high adult mortality) (WHO, 2006).

Improved stoves: The WHO study reports negative BCRs for improved stoves in urban and rural settings, both globally and for Afr-E (African region, high child and very high adult mortality), where Kenya and Uganda are located (WHO, 2006). A BCR of 21.4 observed in our study for Kenya is the result of a mixed intervention of LPG stoves and smoke hoods and therefore not directly comparable to the WHO figures; it is roughly comparable to a BCR of 25 reported for the GTZ *rocket* stove programme in Uganda (Habermehl, 2007).

6.3.2. Distribution of benefits

Health arguments are one, if not the most important, reason for the increased international attention paid to household energy in recent years. A striking conclusion of the WHO CBA, the GTZ CBA and the present study is that direct health benefits appear to make a relatively limited contribution to overall benefit. This conclusion should, however, be interpreted with caution as neither of the three studies assessed all of the health impacts likely to result from traditional household energy use. The GTZ CBA focused only on morbidity as a result of acute disease (Habermehl, 2007); the present study included morbidity but not mortality from ALRI and COPD. The health benefits included in both the WHO CBA and the present study are based on WHO's comparative risk assessment for the year 2002. Since then evidence has accumulated that IAP is not only an important risk factor for childhood ALRI, COPD and lung cancer but can also cause low birth weight (Pope et al., 2010) and a number of other important conditions including cataracts and other cancers (Bruce et al., 2000). In terms of disease burden, the probable link with cardiovascular disease is also an important omission: to date, there are no studies directly linking IAP from solid fuel use to cardiovascular disease, although some studies show an effect on blood pressure (McCracken et al., 2006). Yet the large body of evidence from exposure to combustion-related outdoor air pollution, second-hand smoke and active smoking makes a strong case for such an effect (Pope et al., 2009). Assessing and valuing averted cases and deaths and the full healthcare cost savings and productivity gains relating to all of these health outcomes is likely to increase the relative contribution of health benefits to overall benefits in household and societal CBA.

For the LPG intervention in the WHO CBA, time savings due to less fuel collection were responsible for 49% of overall benefit, followed by health-related productivity gains due to avoided cases and avoided deaths (45%) and environmental benefits (7%) (WHO, 2006). For the improved stove intervention in the WHO CBA, time savings (84%) constituted by far the most important benefit, with health-related productivity gains (14%) and environmental benefits (2%) making relatively minor contributions. The GTZ CBA assumed a short-term reduction in acute respiratory infections, eye irritations and burns among intervention households, but did not consider longer-term reductions in ALRI and COPD or deaths averted (Habermehl, 2007). Associated healthcare cost savings (to individual patients and the health system) and time savings were valued and contributed 7% to the overall economic benefit. Consistent with the findings of the WHO CBA, overall economic benefits in this societal CBA were dominated by fuel savings and time savings.

Health system costs and productivity gains as a result of avoided deaths were not considered in the present analysis. Direct healthcare cost savings among households and time savings as a consequence of avoided illness constitute 0.1%, 0.2% and 2.7% in Kenya, Sudan and Nepal, respectively. If only these benefits are considered separately in the WHO CBA, they make up 1.6% for the LPG intervention and 0.5% for the improved stove intervention, suggesting broadly comparable results. Fuel savings (in Kenya and Sudan) and fuel collection time savings (in Nepal) as well as cooking time savings (in all three countries) are clearly responsible for the greatest overall economic benefit in our study. It is, however, important to note that our valuation of health benefits is very conservative as (i) we included only two of the potentially many important health outcomes, (ii) the true COPD incidence in the three settings is likely to be considerably higher than the figures reported by the WHO and (iii) we did not consider deaths averted.

In summary, independent of the perspective adopted, direct healthcare cost savings are of very limited importance in CBA, and productivity gains as a result of less illness make a minor contribution to overall economic benefit in household CBA and societal CBA. In contrast, deaths averted (so far only considered in the WHO CBA), in particular childhood ALRI deaths with the associated large number of years of life lost, are responsible for a large percentage of overall economic benefit in societal CBA.

7. Conclusions

We carried out a household-perspective CBA for single- and mixed IAP-alleviating interventions in three distinct settings in Kenya, Sudan and Nepal. For all three, benefits exceed costs over a ten-year intervention period, suggesting that several household energy interventions not only produce health benefits but also make good economic sense. Benefit-cost ratios and internal rates of return vary markedly between settings. Similarly, the distribution of benefits shows considerable variation, mainly according to whether fuel is purchased or collected, and as a result of the amount of cooking time saved. One notable and consistent observation is the relatively small contribution from direct health benefits accruing due to reductions in IAP exposure.

Arguably, several of our assumptions are subject to considerable uncertainty. While we did not conduct formal one-way or probabilistic sensitivity analysis, given the distribution of benefits it is clear that overall cost-benefit results are much affected by valuation of time savings and choice of discount rate. Valuing time savings more conservatively (for example, at ½ GNI per capita or at the minimum wage rate rather than at GNI per capita) would reduce economic efficiency in all three countries; in Nepal, it may result in the costs of the intervention exceeding its benefits. Some household perspective cost-benefit analyses employ discount rates exceeding 10%. The very high internal rates of return for Kenya and Sudan suggest that such a change would not affect our conclusions about economic efficiency; in Nepal, on the other hand, a discount rate of 19% would result in a net present value of zero and even higher discount rates would yield a negative net present value.

Several of the challenges we encountered when conducting a 'real-life' CBA will need to be tackled. In particular, planning for CBA by selecting appropriate target populations and collecting data in the context of an ongoing development programme, whose natural evolution must not be disrupted, is critical. Household-level CBA should include a broader range of benefits and drawbacks as perceived by householders, including general aspects of well-being and impacts on the local and, where applicable, global environment. The assessment and valuation of health benefits also warrants further attention, in particular in relation to health benefits included, true incidence and prevalence of different diseases and levels of healthcare provision. Finally, future CBAs undertaken as part of local programmes should more formally examine the impact of uncertainties in assumptions about key parameters on results, and explore alternative ways of valuing benefits including willingness-to-pay.

In this study, CBA results were used as a means of providing feedback to participating households, the implementing agency and the funding agency. They show that it pays off, from a household perspective, to invest in improved household energy. Nevertheless, high upfront investment costs for smoke hoods, improved biomass stoves or cleaner-fuel stoves represent a barrier that prevents poor households from adopting—and IAP continues to be one of the main causes of ill-health in poor communities of developing countries. Therefore, using the economic efficiency argument in the pursuance of policy development and implementation at national, regional and international levels are all the more important. We hope that our study, along with many more such studies, will help to secure more widespread political and policy attention to the issue, to develop more flexible and locally appropriate commercial approaches and to open up new ways of funding for the promotion of IAP-alleviating interventions.

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Cost-Benefit Analysis and European Union Cohesion Policy: Economic Versus Financial Returns in Investment Project Appraisal[1]

Abstract: This paper investigates the role of cost-benefit analysis (CBA) in the context of the European Union (EU) Cohesion Policy. After presenting the EU policy framework and the CBA guidelines adopted by the European Commission, we perform an empirical analysis drawing from a dataset of around 1000 major project applications, submitted during the period 2007–2013 by 22 European countries, and representing almost €180 billion of investment. A distinctive feature of the current CBA approach adopted by the European Commission is that applications for funding must provide a forecast of both the project's financial rate of return (FRR) and economic rate of return (ERR). While the former represents the financial profitability of the project from a private investors' perspective, the latter reveals its socio-economic benefits for the whole society. The difference between ERR and FRR mainly depends on the use of shadow prices, the inclusion of externalities and other nonmarket effects in the estimation of ERR, whilst the FRR is based on market prices. We find that, on average, the FRR is slightly negative (−2.9%) and the ERR is positive (16.2%). ERR and FRR are positively correlated on average with differences across sectors. We discuss these findings and suggest further research needs.

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JEL classifications: H43; H54; R58.

1 Introduction

The Cohesion Policy is the most important investment policy of the European Union (EU); it aims at reducing the wide regional disparities existing in Europe,[2] by supporting economic growth and sustainable development of regions and cities, favoring job creation and business competitiveness, as well as improving quality of life of EU citizens, particularly in lagging behind regions (European Commission, 2016*a*). The core of this policy is a coordinated mechanism of investment, primarily in the form of capital grants, disbursed by the EU to the Member States in addition to their national public spending.

This paper investigates the role of CBA, a methodology with a long tradition for the evaluation of public investment, in the context of the EU Cohesion Policy. At the European Commission (EC) level, CBA was first introduced in 1994 by the Directorate General for Regional Policy, with the release of the first CBA Guide. Since then, the Cohesion Policy has gradually promoted the practice of CBA, which has become today a mandatory requirement for applications of major projects whose total eligible cost exceed €50 million.[3] Five subsequent editions of the Guide (European Commission, 1994, 1997, 2002, 2008, 2014) have laid down the rules for project appraisal.

In order to apply for EU funds, Member States are required to present a financial and economic analysis of the investment project. A necessary requirement for obtaining the grant is that the project is not financially attractive for capital markets while economically efficient from the point of view of the society. In fact, a distinctive aspect and considerable advantage of the EC approach to CBA is that the estimation of both projects' financial rate of return (FRR) and economic rate of return (ERR) is required in funding applications. While the former gives an indication of the project's financial profitability and must be negative (or below the profitability level required by private investors), the latter shows whether the project is beneficial

2 For example, the Gross Domestic Product per head in Purchasing Power Parity in Baden-Württemberg (Germany) is €41,300 versus €9,600 in Yuzhen Tsentralen (Bulgaria) (Eurostat, 2017).

3 €75 million in case of operation falling under Article 9(7) of Reg. 1303/2013 (European Union, 2013; European Commission, 2014). Beside the Cohesion Policy, a CBA is also required for other EU funding instruments such as the Connecting Europe Facility and the European Fund for Strategic Investments, among others.

for the society and should therefore be higher than the social discount rate (SDR), as explained in Section 3.

This paper considers, project by project, the relation between ERR and FRR as a summary indicator of the role played by CBA in the appraisal process. In fact, such relation shows how extensively the use of shadow prices, the inclusion of externalities, and in general of nonmarket effects, readjusts the economic evaluation of the project compared to the financial one. In this perspective, the divergence for each project between ERR and FRR can be considered as a proxy indicator of the CBA role in taking into account market distortions and capturing the expected social benefits of the project, beyond its profitability from a simple financial point of view. Hence, we ask two simple questions in this paper: to what extent has CBA introduced corrections to the financial analysis, when performing an economic appraisal of major projects submitted to the EU during the last programming period? What are the main drivers of such corrections?

After presenting the development of the CBA practice over the last years in the context of the Cohesion Policy, we report some statistical evidence based on *ex ante* CBA of around 1000 projects appraised during the period 2007–2013, representing almost €180 billion of total investment cost. This appraisal is usually carried out by Members States, and the preparation of the CBA documentation is largely assisted by experienced consultants or by experts of JASPERS.[4] In the considered period, project applications were systematically appraised by the staff of the EC in some cases with the support of independent consultants. Our analysis focuses exclusively on data from Cohesion Policy grants applications; we do not have access to data on other projects for which Member States have decided not to apply for the EU grants. Moreover, we cannot control for optimism bias of the applicants or any issue of asymmetric information, neither this paper analyzes the subsequent history of the project, such as the EC decision on disbursing the grant or the implementation processes (e.g., some projects have been withdrawn, and some of them modified in terms of scope and/or timing). Our focus is limited to the *ex ante* appraisal at the time of the application, and particularly on CBA.

We find that, on average, the expected FRR is slightly negative (−2.9%), while the ERR is largely positive (16.2%); this suggests that, according to the applicants, proposed projects are expected to be beneficial for the society, although they are still not attractive for private investors. Moreover, by using simple econometric techniques, we find that ERRs and FRRs are positively correlated, but to a different extent in different sectors. By controlling for the size of investment, the time horizon of the CBA analysis, the location of the project, we find that projects in

4 JASPERS – Joint Assistance to Support Project of European Regions is a special initiative of the European Commission, European Investment Bank and European Bank for Reconstruction and Development.

information and communication technology (ICT), roads and motorways and productive service show a higher ERR compared to the FRR. We discuss possible interpretations of these empirical findings, which are novel and not obvious. In fact, the relation between ERR and FRR can be weaker when (positive) externalities are very important (e.g., in some transport and environmental projects) and when shadow and market prices considerably diverge.

The rest of the paper is organized as follows: Section 2 presents the changing landscape of the Cohesion Policy over the last twenty years and the development of the CBA Guide since the release of its first edition in 1994 until the current one. Section 3 summarizes the most important feature of the CBA approach adopted and discusses some key parameters and important methodological issues. Section 4 presents a simple framework to empirically investigate the relation between ERR and FRR of projects evaluation, looking at data from a large sample of major projects appraised in the programming period 2007–2013. Section 5 presents the results of the empirical analysis while the concluding Section 6 discusses lessons learned from the analysis of *ex ante* CBA in the framework of Cohesion Policy, and challenges ahead for further research.

2 Background: the increasing importance of the CBA guide in response to the changing landscape of the EU Cohesion Policy

Since the European Economic Community was established in 1957 with the Treaty of Rome by six founder states,[5] and particularly after the first enlargement in 1973 where Denmark, Ireland and the United Kingdom obtained the EU membership, the regional policy has endured important transformations in terms of main objectives, financial tools available, allocated budget and so on (Goulet, 2008). In this evolving scenario, where the Cohesion Policy began to assume an increasingly high importance and the amount of allocated funds was rapidly growing, the practice of CBA started acquiring a stronger relevance and legal power which made it become the key tool to rule applications for funding of major investment projects by Member States. Table 1 presents an overview of the main objectives of the Cohesion Policy, allocated budget, country membership following the process of EU enlargement, different editions of the CBA Guides and their legal base, during five different programming periods.

5 Belgium, France, Germany, Italy, Luxembourg and Netherlands.

Table 1 The evolution of the CBA guide in response of the changing landscape of the Cohesion Policy (1988–2020).

	1988 - 1992	1994 - 1999	2000 - 2006	2007 - 2013	2014-2020
Cohesion Policy budget	ECU 64 billion	ECU 168 billion	€213 billion for the 15 existing members; €22 billion for the new member countries (2004-06)	€347 billion	€351.8 billion
Member States	EU 12 = 6 Founder States (Belgium, France, Germany, Italy, Luxemburg) + Denmark, Ireland, United Kingdom (joined in 1973) + Greece (joined in 1981)	EU 15 = EU 12 + Austria, Finland and Sweden (joined in 1995)	EU 25 = EU 15 + Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia (joined in 2004)	EU 28 = EU 25 + Bulgaria, Romania (joined in 2007) + Croatia (joined in 2013)	EU 28 = EU 25 + Bulgaria, Romania (joined in 2007) + Croatia (joined in 2013)
Cohesion Policy's priorities	**Objective 1:** promoting the development and structural adjustment of regions whose development is lagging behind; **Objective 2:** converting regions seriously affected by industrial decline; **Objective 3:** combating long-term unemployment; **Objective 4**: facilitating the occupational integration of young people **Objective 5:** (a) speeding up the adjustment of agricultural structures and (b) promoting the development of rural areas.	**Objective 1:** promoting the development and structural adjustment of regions whose development is lagging behind; **Objective 2:** converting regions or parts of regions seriously affected by industrial decline; **Objective 3:** combating long-term unemployment and facilitating the integration into working life of young people and of persons exposed to exclusion from the labour market, promotion of equal employment opportunities for men and women; **Objective 4:** facilitating adaptation of workers to industrial changes and to changes in production systems; **Objective 5:** promoting rural development by (a) speeding up the adjustment of agricultural structures in the framework of reform of common agricultural policy and promoting the modernisation and structural adjustment of the fisheries sector, (b) facilitating the development and structural adjustment of rural areas **Objective 6:** development and structural adjustment of regions with an extremely low population density.	**Objective 1** (ERDF): promoting the development and structural adjustment of regions whose development is lagging behind; **Objective 2** (ERDF and ESF): supporting the economic and social conversion of areas facing structural difficulties. **Objective 3** (ESF): supporting the adaptation and modernisation of policies and systems of education, training and employment.	**Convergence:** aims at speeding up the convergence of the least-developed Member States and regions defined by GDP per capital of less than 75 % of the EU average; **Regional Competitiveness and Employment:** covers all other EU regions with the aim of strengthening regions' competitiveness and attractiveness as well as employment; **European Territorial Cooperation:** based on the Interreg initiative, support is available for cross-border, transnational and interregional cooperation as well as for networks.	**(1)** strengthening research, technological development and innovation; **(2)** enhancing access to, and use and quality of ICT; **(3)** enhancing the competitiveness of SMEs, of the agricultural sector (for the EAFRD) and of the fishery and aquaculture sector (for the EMFF); **(4)** supporting the shift towards a low-carbon economy in all sectors; **(5)** promoting climate change adaptation, risk prevention and management; **(6)** preserving and protecting the environment and promoting resource efficiency; **(7)** promoting sustainable transport and removing bottlenecks in key network infrastructures; **(8)** promoting sustainable and quality employment and supporting labour mobility; **(9)** promoting social inclusion, combating poverty and any discrimination; **(10)** investing in education, training and vocational training for skills and lifelong learning; **(11)** enhancing institutional capacity of public authorities and stakeholders and efficient public administration
CBA guide editions	–	CBA guide (1994)/ (1997)	CBA guide (2002)	CBA guide (2008)	CBA guide (2014)
Legal base of the CBA guide	–	Art.14, Reg 2082/93 (SF) (EU, 1993a) Art.5, Reg.2083/93 (ERDF) (EU,1993b) Art 10 (5) Reg 1164/94 (CF) (EU, 1994)	Art. 26, Reg.1260/99 (SF) (EU, 1999a) Reg 1164/1994 and 1264/99 (CF) (EU, 1999b, 1999c) Art.7, Reg, 1267/1999 (ISPA) (EU,1999d)	Art 40, Reg. No 1083/06 (SF) (EU, 2006a) Implementing Regulation-Corrigendum (Reg. 1828/06) (EU, 2006b) Reg. 1260/99 (EU, 1999a) Art. 157, Imp Reg. 718/07 (IPA)(EU,2007b)	Regulation 1303/13, Delegated Reg. 480/2014; Implementing Reg. 1011/14; Implementing Reg. 207/2015 (EU, 2013, 2014a, 2014b, 2015)

Notes: Structural Funds (SF) - European Regional Development Fund (ERDF) - Cohesion Fund (CF) - ISPA (Instrument for Structural Policies for Pre-Accession) - IPA (Instrument of Pre-Accession Assistance).

Source: Own elaboration based on the EU website and on different editions of the CBA guides

Before 1987, applications for Structural Funds[6] were left at the discretion of national governments and mostly considered as a sort of reimbursement for their contribution to the community budget (Sutcliffe, 2000). However, after 1987 with the Single European Act, the Commission decided to start earmarking a five years budget for the Cohesion Policy, thus calling for a need to have common guidelines to evaluate and compare *ex ante* different project applications of Member States. In 1993 and 1994, the EC regulation governing Structural and Cohesion Fund[7] started to require a CBA, as long with other types of information and the EC commissioned to a team of experts the first edition of its CBA Guide (European Commission, 1994); this was a brief document of 28 pages, without any legal status, just intended to bring some discipline in the applications of European Regional Development Fund (ERDF) which were very heterogeneous. In this respect, a study conducted by Florio (1997) on a sample of major projects co-financed during the period 1988–1993 shows the severe dispersion in some key parameters of CBA, also highlighting the fact that key items of CBA were available only for few applications.

The second version of the Guide (84 pages) (European Commission, 1997) presented minor methodological changes compared to the previous edition whilst the use of the Guide was also extended to the appraisal of Cohesion Fund (CF) applications. A third augmented edition of the Guide released in 2002 (European Commission, 2002) consisted of 135 pages. As Table 1 shows, the legal bases of this new guide laid on a new set of updated regulations for Structural Funds, CF and ISPA[8] applications, providing further and more specific indications on how to carry out the appraisal.

A major transformation of the Cohesion Policy took place in the period 2000–2006, following the biggest enlargement of EU. This enlargement, which saw ten new countries mainly from Eastern Europe obtaining the EU membership in 2004,[9] significantly amplified the disparities among regions as the EU's population increased by 20% whilst its GDP only by 5% (European Commission, 2017). Figure 1 presents the geographical distribution of those regions whose GDP per head at Purchasing Power Parity (PPP) was inferior to the EU 27 average,[10] in the year of the enlargement. As the figure shows, lower income regions were mainly

6 Structural Funds (SF) included the European Social Fund (ESF) and the European Regional Development Fund (ERDF) which together with the Cohesion Fund (CF) represent the most important funds of the Cohesion Policy.

7 Art. 14, Reg. 2082/93 and Art. 10(5), Reg. 1164/94 (European Union, 1993*a*, 1994).

8 The Instrument for Structural Policies for Pre-Accession (ISPA) was set up to promote the catching up of future members in terms of environmental and transport infrastructure (European Commission, 2016*c*).

9 Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia.

10 Including Romania and Bulgaria that joined the EU in 2007.

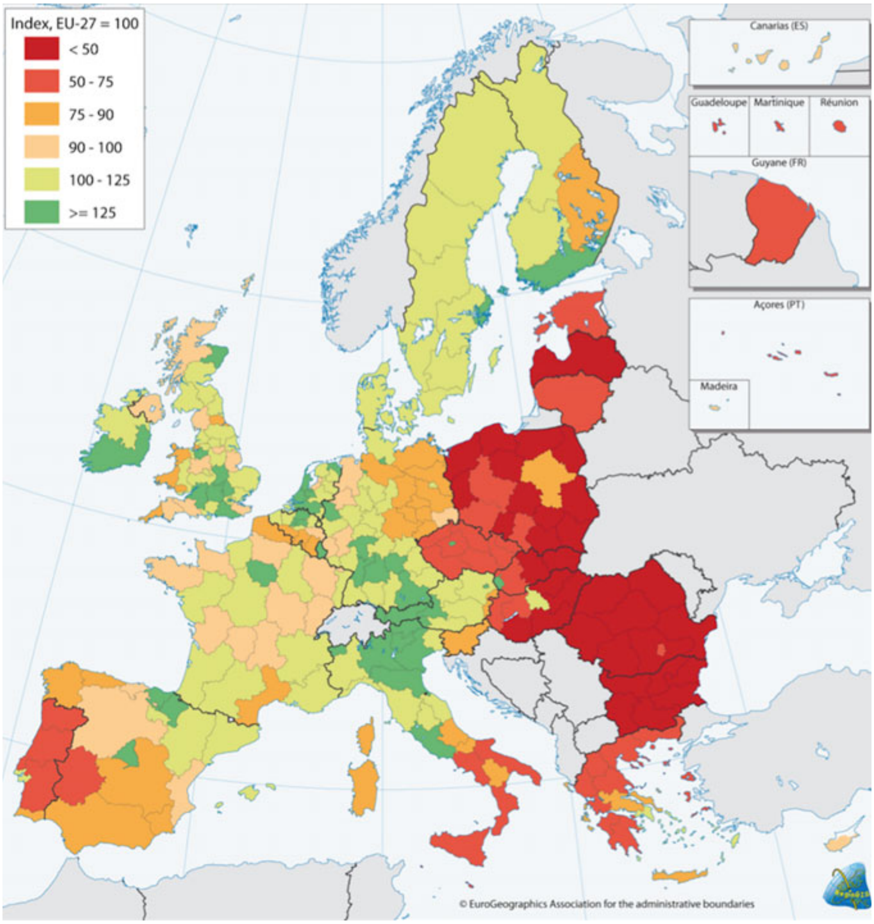

Figure 1 GDP per head at PPP during the year of the biggest enlargement (2004). *Source:* European Union (2007*a*, p. 8).

concentrated in New Member States, but also in Portugal, Greece and Southern Italy.

During the following period 2007–2013, relevant for the analysis of project applications undertaken in this paper, two other Eastern countries, Bulgaria and Romania, joined the community. The EU allocated €347 billion for Cohesion Policy, with the highest concentration of funds earmarked for lagging regions (Dijkstra, 2014; European Commission, 2017). In terms of investment composition, there was also a shift of priorities in less developed regions from infrastructure development toward business competitiveness and innovation goals (Dijkstra, 2014). Moreover, compared to the previous period, a larger number of actors at a different level were involved in the selection process such as different managing authorities and EC services. This emphasized the necessity to have clearer guidance and common rules to select the best projects and facilitate learning mechanisms among players (European Commission, 2008). To allow for timely preparation of projects, the Working Document n.4 was published in 2006 by the EC, leading toward higher levels of consistency and rigor in conducting CBA (European Commission, 2006). This document also introduced an updated and more effective mechanism to calculate the base of the EU grant, as explained in the next section, and was followed by the fourth edition of the Guide (European Commission, 2008). The methodological development of the new Guide was favored by the experience gained through the use and application of the previous editions especially after the period of enlargement (European Commission, 2008). Although it was still considered as a set of suggestions, for the first time the EC had to check whether different applications were coherent with this guidelines, for example, in terms of working hypotheses and methods used for the calculation of performance indicators (European Commission, 2008).

Finally, the latest and current version of the Guide was released in 2014 and consists of 358 pages. The Guide offers comprehensive guidance for performing CBA and presents specific recommendations and case studies for five main sectors (transport, environment, energy, broadband, and Research & Development (R&D)) according to the priorities of the period 2014–2020. Today, CBA is mandatory to apply for co-funding (ERDF and CF) and the 2014 Guide, is backed by the EU legislation. Thanks to the Implementing Commission Regulation 207/2015 (European Union, 2015) setting out in a legally binding manner the main principles of conducting the CBA, the 2014 Guide can be now considered the reference point for all managing authorities and those involved in the project appraisal (European Commission, 2014).

3 The economic and financial analysis of projects: key methodological issues

In this section, we briefly summarize the main methodological CBA approach adopted by the EU, which is consistent across the five editions of the guide. In particular, we refer to the more recent CBA Guides (there are no significant differences between the 2008 and 2014 editions). A key and distinctive aspect of such approach is that the application for funding requires both a financial and an economic analysis of projects within a consistent accounting system. Here we first introduce both types of analysis and then we focus on the relation existing between the two.

3.1 Financial analysis

The main purpose of the financial analysis is to assess whether the project is sustainable and/or viable from a financial point of view. In this respect, the financial net present value (FNPV) gives an indication of the ability of the project's net revenues to repay the initial investment, regardless of the sources of financing; it is calculated as a difference between the expected investments and operating costs less the expected revenues, all values discounted and net of potential avoided costs and occurred benefits in a counterfactual scenario (otherwise called "without the project" scenario).[11] The EC Guide adopts the Discounted Cash Flow method which consists in discounting project' costs and revenues, usually expressed in real terms, with a reference Financial Discount Rate (FDR), for a time horizon which varies depending on the sector. This represents the opportunity cost of the capital[12] and is calculated looking at possible returns of alternative financial investments. The average financial rate of a mix of securities, suggested by the Guide as a reference point for the financial analysis of EU projects in the period 2007–2013 which is relevant for this analysis, was 5% in real terms[13] (European Commission, 2008).

The estimation of the FRR defined as the discount rate that produces a FNPV equal to zero is also required to project applicants. The calculation of both the FNPV and the FRR is based on observable market prices. A project in need of financial support and therefore eligible to receive a EU grant, should present a negative FNPV meaning that it is not profitable from a financial point of view as it is not able to generate sufficient revenues given the reference FDR.[14] At the same time, the FRR which is a scale-invariant pure number, should assume a lower value compared to the FDR (European Commission, 2008, 2014).

Before introducing the economic analysis, we discuss the pro-rata application of the discounted net revenues (Implementing Reg. 207/2015), formerly known as "funding gap method," which is often used as the base for the grant calculation. This approach is based on the idea that the EU grant should only co-finance the portion of investments which is not covered by future net revenues (Florio & Vignetti, 2012) and is also used to create incentives for attracting private capital, besides the EC contribution (Mairate, 2010). The pro-rata application of the discounted net

11 A counterfactual scenario is defined as "what would happen in the absence of the project" European Commission (2014, p. 26).

12 The opportunity cost is defined as "the potential gain from the best alternative forgone, when a choice needs to be made between several mutually exclusive alternatives" European Commission (2014, p. 25).

13 This benchmark has been reduced to 4% in the Guide 2014 (European Commission, 2014).

14 This does not necessarily apply to projects subject to State Aid rules.

revenues is calculated as follows:

$$\text{Pro-rata application of the discounted net revenues} = (\text{Inv} - \text{NetRev})/\text{Inv}, \quad (1)$$

where Inv is the net present value of the investment costs and NetRev is the net present value of the difference between revenues and operating costs plus the residual value of assets (all values discounted using the FDR). A limitation is that usually investment costs incur in the early years of the projects and are not much affected by high FDR, while revenues accrue later; this may translate into inflated funding gap rates increasing the possibility to request higher grants to what is actually needed (Florio & Vignetti, 2012). Another drawback is that applicants may have an incentive to overestimate costs and underestimate revenues in order to require higher grants. In this perspective, according to the currently adopted "grant decision framework," the EU should not cover the whole financial gap and the EU grant should be calculated as follows:

$$\text{EU grant} = \text{Pro-rata application of the discounted net revenues} * \text{EligibleCost} * \text{MaxCR}, \quad (2)$$

where EligibleCost is the cost remaining after deducting ineligible costs from the total costs of the major project (European Commission, 2016*b*); MaxCR is the maximum co-funding rate fixed for each priority activities. This mechanism meant to ensure that the EU grant does not cover the full financial gap as it was happening before 2006, but only co-finances it (Mairate, 2010).[15]

3.2 Economic analysis

After conducting the financial analysis, the subsequent economic analysis consists of checking whether the project is desirable from a social point of view.[16] As for the financial analysis, social costs and benefits should also be net of potential avoided costs and occurred benefits in a counterfactuals scenario. However, with respect to the financial analysis, the economic analysis introduces important corrections

15 In order to further simplify the EU grant calculation, in the 2014–2020 programming period, there are two possible ways to deduct potential revenues from the project: 1) calculation of net revenues for a specific project, 2) application of net revenue flat rate percentage for sector/subsector (that can be also integrated into the co-financing rates of the priority axis). The rates are: 30% for road sector, 25% for water sector, 20% for rail, waste, urban transport, and R&D (CSIL, 2015).

16 Some experts argue that for not-revenue generating infrastructure (e.g., nontolled public road) it is more appropriate to start from economic analysis, and even ignore computation of financial profitability indicators.

which include the use of shadow prices the consideration of externalities and non-market effects, as explained later in this section.

First, to discount social costs and benefits the economic analysis uses the SDR that "reflects the social view on how future benefits and costs should be valued against present ones" (European Commission, 2008; European Commission, 2014, p. 55). In perfectly competitive markets the SDR and FDR coincide; however this does not happen in real life as markets are often inefficient (Florio, 2006). To calculate the SDR, the Social Rate of Time Preference (SRTP) is the method adopted by the Guide (HM Treasury, 2003; Hepburn, 2007; Hagen et al., 2012); this reflects the rate at which a certain society is willing to postpone its consumption today in exchange of higher level of consumption in the future (Arrow, 1999). Although the SDR can be estimated with different methods, the Guide suggests the adoption of the Ramsey (1928)'s formula of economic growth and which defines SDR as follows:

$$\mathrm{SDR} = e * g + ptp, \tag{3}$$

where g is the expected growth rate of a macroeconomic variable used as a proxy of welfare, usually consumption per capita; the idea is that whether future generations will be richer than present ones, the SDR will increase, thus giving more importance to present (and poorer) generations. e is the elasticity of marginal social welfare with respect to consumption and measures how much worthy is to transfer income from future richer generations to present poorer ones.[17] *ptp* is the rate of a pure time preference which includes two components: the first captures the fact that individuals usually prefer consuming today rather than tomorrow; the second takes in consideration the risk of death of human beings and may be captured by the mortality rate. When *ptp* is positive, the welfare of current generations is preferred to future ones. While estimates for g are easily available, applied economic research is needed to estimate the other parameters.

With respect to the Ramsey's formula it is important to highlight that consumption growth depends on GDP growth which considerably varies across different EU countries and regions, in particular when looking at the current composition of EU28, which encompasses highly heterogeneous countries. In fact, growth rates of New Member States are much higher compared to EU15 countries and this is the main reason why the last two versions of the Guide, following the methodology proposed by Florio (2006), suggest adopting two different SDRs: 5% for cohesion countries and 3% for the other Member States. Hence, whilst the Guide

17 The formula adopted is $e = \log(1 - t)/\log(1 - T)$ where t is the marginal income tax rate, T is the average income tax rate (Stern, 1977; Cowell & Gardiner, 1999; Evans, 2005; Groom & Maddison, 2013).

recommends a single FDR for all EU28, the use of a higher SDR to discount project's costs and benefits in cohesion countries compared to EU15, reflects the higher importance given by the Cohesion Policy to the welfare of present generations in most deprived areas.[18]

As previously introduced, another important difference between the economic and financial analyses is that whilst the former evaluates cash flows at market prices, the latter uses shadow prices (Drèze & Stern, 1987, 1990; Londero, 2003). Shadow prices capture the opportunity costs of goods and services as market prices are often distorted due to inefficiencies (e.g., situation of monopoly, subsidies, etc.) particularly in EU lagging regions (OECD, 2015).

To calculate shadow prices the Guide suggests different methods based on the standard literature. With respect to project's inputs, if these are tradable (e.g., raw materials), the Guide recommends the application of "border price," thus excluding custom duties or other taxes applied after these goods cross the national border (Little & Mirrlees, 1974; Saerbeck, 1990; European Commission, 2008). If inputs are not tradable, a standard conversion factor is used for minor items such as administrative costs whereas for other major items (e.g., land) long-run marginal cost is adopted.

With respect to labor, regional shadow wages are calculated following the methodology suggested by Del Bo, Fiorio and Florio (2011). This methodology takes into account heterogeneous labor markets across EU regions where market wages do not often reflect the real opportunity cost of labor due to wages rigidities, the existence of legal minimum wages and other structural reasons. The general formula used to calculate the shadow wage rate (SWR), under the assumption that all workers' income is spent on consumption is:

$$\mathrm{SWR}_r = \beta_r m_{1,r} + (1 - \beta_r) w_{2,r}, \tag{4}$$

where r is a certain EU region, m_1 is the marginal productivity of the worker which will be displaced by the project from one sector to another, w_2 is a proxy of wage in a competitive market where the worker will be employed thanks to the project and β is a regional welfare weight. The idea behind this formula is that, when a worker is displaced from an activity to another one, the opportunity costs which capture what the economy has lost, is given by the worker's output in his previous activity. However, this formula takes into account that every time a worker is displaced from his/her previous work there could be social costs such as transport, training

18 In practice, there is no choice between consumption and investment in Cohesion Policy; as it is, the policy focuses solely on investment, however in areas with low endowment of infrastructure and low private investment, it is expected that public infrastructure projects should bring substantial economic returns to justify public investment.

and other opportunity costs that are not entirely captured by market wages. Thus SWR considers the net social cost of labor of a region as "a welfare-weighted linear combination of the previous (*ex ante*) and of the current (postproject) social value of the new job opportunity" (European Commission, 2014, p. 314).

According to the methodological approach suggested by the Guide, this general formula is then re-adapted to reflect different regional specificities of the EU. More specifically, Del Bo et al. (2011) identify four clusters of regions in terms of employment, wage rigidities, migration flows, urban–rural dualism and so on. The use of regional shadow wage constitutes a significant methodological advancement of the Guide and it is in line with the overall objectives of the Cohesion Policy of achieving growth, convergence and reducing unemployment. Unfortunately we do not have systematic data about the values of shadow wages used in the applications, but visual inspection suggests that shadow wages are mostly adopted using shortcuts based on unemployment rate (see European Commission, 2014; p. 59 for further info).

With respect to the project's outputs, these are here calculated through the willingness to pay (WTP) principle, which measures the maximum amount that people are keen to pay for a desirable outcome. WTP can be estimated through different techniques (Johansson & Bengt, 2015), for example, by calculating the saved costs that would have incurred if users had bought the same good from an alternative source.

Apart from the estimation of the shadow prices, another important characteristic of the economic analysis is that it should include externalities and nonmarket effects. These comprise, for example, the impact on the quality of life, the production of project's externalities such as noise, soil contamination, deterioration of landscapes and GHG emissions among others (Johansson, 1987). Environmental aspects are particularly important since Europe is becoming more and more interested in supporting environmentally friendly activities and in promoting higher efficiency in resource management (Dijkstra, 2014). Considering the environmental impact of the project on landscape, pollution, waste production and so on, it is essential to reveal the real economic benefit of the project for the society. Due to their nature, positive or negative externalities and nonmarket effects need to be assessed separately often using the WTP approach. Although, in recent years, significant progress has been made to give credit to costs and benefits that spillover from the project without monetary compensation, additional theoretical and empirical efforts are still needed (European Commission, 2008, 2014).

In conclusion, projects eligible for EU funding, apart from being in need of cofinancing, should present a positive economic net present value (ENPV) meaning that the project's overall benefits for the society are expected to exceed the social costs, all values discounted with the SDR. Another indicator measuring the project economic performance is the ERR which is defined as the rate that produces a zero ENPV. Like the FRR, it is a scale-invariant pure number; when the ERR is higher than the SDR and the ENPV is positive the project is worthy to be implemented (European Commission, 2008, 2014).

4 Framework of the empirical analysis and descriptive statistics

As previously mentioned whilst FNPV and FRR are based on market prices, ENPV and ERR are based on shadow prices and take into account externalities (European Commission, 2008, 2014). This lead to the following equation valid for each project i:

$$\mathrm{ENPV}_i - \mathrm{FNPV}_i = \sum_{t=1}^{T} (vq_i)/(1+\mathrm{ERR}_i)^t - \sum_{t=1}^{T} (pq_i)/(1+\mathrm{FRR}_i)^t = 0, \quad (5)$$

where p is a vector of market prices, v is a vector of shadow prices, q_i is a project-specific vector of quantities of inputs and outputs for n goods, while t is the time horizon of the analysis. Externalities are simply the case of inputs or outputs valued zero by markets whilst different from zero values when using shadow prices. By definition ENPV $=0$ when the internal rate of return ERR is entered in the formula, and similarly FNPV $=0$ when the internal FRR is used, because internal rates of return are defined as those rates that lead to zero NPV (Boardman, Greenberg, Vining & Weimer, 2001; European Commission, 2008, 2014). Hence, the difference of ENPV of FNPV must also be zero when, respectively, the ERR and FRR are used to compute them. From (5) it follows that a condition for $\mathrm{ERR}_i = \mathrm{FRR}_i$ to hold, it is that market prices are equal to shadow prices for each of the n goods and there are no externalities ($p_n = v_n$). In this perspective, the divergence between ERR and FRR for each project can be considered as a proxy indicator of the CBA role in taking into account market distortions.[19]

In general, given the objectives of the EU Cohesion Policy, we expect that selected projects are those where FRRs are lower than FDRs; in fact such projects would not have been financed by capital markets although beneficial for the whole

19 With the exception of transport where partial equilibrium model was used leading to exclusion of tariff from economic analysis. The economic evaluation of transport projects is traditionally based on a partial equilibrium approach. For this sector economic benefits are obtained by adding the consumer with the producer's surpluses and not by applying conversion factors to the project revenues.

society. However, this does not imply that FRRs and ERRs are inversely correlated. In fact, with the exception of externalities where $p = 0$, in general $v = cp$, where c is a conversion factor (Little & Mirrlees, 1974; Londero, 2003), hence $v - p = v(1 - \frac{1}{c})$. The correlation between ERR and FRR given in equation (5) is tested empirically later.

CBA, as conceived in the framework of the Cohesion Policy, is useful to determine whether the project is actually in need of co-financing and desirable from a socio-economic perspective. If the FNPV is negative (the FRR is relatively low) whilst the ENPV is positive (the ERR is relatively high), the project is not attractive for capital markets although beneficial for the society and therefore worthy to be financed and implemented. The combination of the financial and economic analyses represents an important advantage for a fairer allocation of the grants. First, an important strength of this combined approach is given by the fact that applicants who may tend to overestimate project's market benefits are likely to present higher financial revenues and therefore receive smaller grants.[20] Second, by carrying out the economic analysis following the principles suggested by the Guide, corrections of market failures are introduced in the portfolio of major projects which are selected for funding. These corrections mainly operate thanks to the mechanism of converting market prices into shadow prices and considering projects' externalities and other nonmarket effects. The double assessment, financial and economic, highlights the importance of empirically studying the relation existing between FRR and ERR.

Our original dataset included over 1000 project applications, representing the entire population of project applications for ERDF and CF during the period 2007–2013.[21] In this perspective, the issue of sample selection is a minor one (although, as mentioned in Section 1, we could not consider projects funded outside the EU grant mechanism). Before starting the analysis, we had to carefully clean the database from outliers and inconsistencies in data. For each relevant variable, such as total investment cost, ERR, FRR, FNPV and ENPV, we divided the relative distributions in percentiles, dropping observations if the corresponding value belonged to the 1st or 99th percentile. The dataset was therefore reduced to 945 projects; however due to the presence of missing data in some of the main variables of interest, estimations could be based on 762 observations only. We checked that the final sample was still representative of the original dataset in terms of the main variables of interests. The following descriptive statistics refer to the restricted sample.

20 This is particularly relevant for productive investments that had an appetite for capital grants instead of using financial instruments more appropriate to their financial performance.

21 The Commission approved 970 major projects of total cost of €155 billion in the 2007–2013 programming period.

Table 2 Number of projects by sector (2007–2013).

Transport	**343**
Road and Motorways	*124*
Railways	*101*
Other Transport	*118*
Environment & Environmental Infrastructure	**244**
Management and distribution of water	*115*
Management of household and industrial waste	*34*
Other environmental services	*95*
Other Sectors	**175**
Research and development and innovation	42
Energy infrastructure	36
Information and communication technology (ICT)	31
Productive investment	31
Health infrastructure	21
Others	14
Tot.	**762**

Notes: Sector classification taken and re-elaborated from the Commission Implementing Regulation (EU) No. 215/2014 of 7 March 2014 (European Union, 2014*c*). "Other Transport" includes ports and inland waterways, local transport, air transport, multimodal transport, sustainable transport. "ICT" includes both demand stimulation, applications, services and infrastructure. "Other environmental services" includes also cultural heritage and cultural infrastructure. "Others" includes: Business development, Education & Education Infrastructure and projects for urban and rural regeneration.
Source: Own elaboration on data provided by Directorate General for Regional and Urban Policy (2017).

Projects are located in 22 European countries and three macrosectors; as Chart 1 shows, around 66% of these projects are located in New Member States,[22] with Poland (185) and Romania (94) showing the highest number of applications. Appendix shows the sector composition at the country level.

At the sector level, Table 2 shows that the highest number of projects is concentrated in the transport sector (343) and environment (244). The number of projects in R&D, energy, ICT, and industry is in the range 30–40 for each sector whilst the remaining projects are in health, cultural heritage and other sectors such as education and urban regeneration.

The highest EU contribution requested by the applicants out of total investment is for environmental projects (around 60%) while the lowest for Produc-

22 New Member States here are Bulgaria, Czech Republic, Estonia, Croatia, Hungary, Lithuania, Latvia, Malta, Poland, Romania, Slovenia, Slovakia; EU15 countries are: Austria, Germany, Spain, France, Greece, Ireland, Italy, Portugal, United Kingdom.

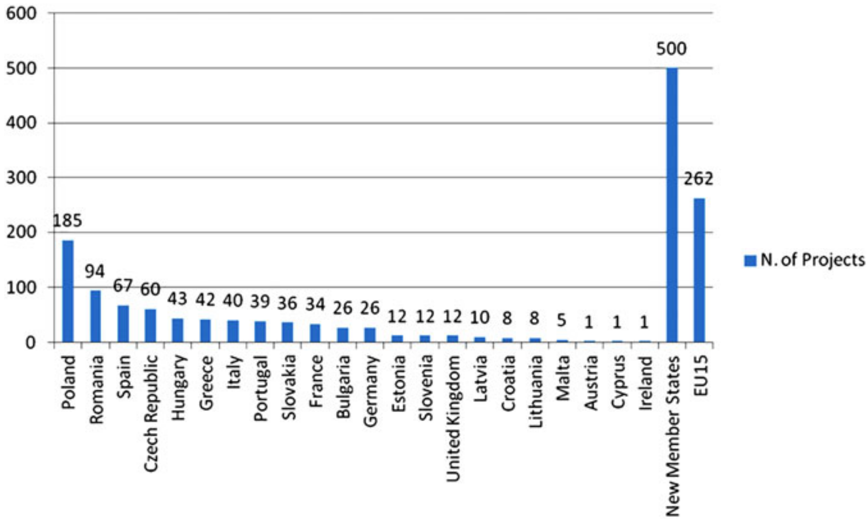

Chart 1 Project applications by country (2007–2013). *Source:* Own elaboration on data provided by Directorate General for Regional and Urban Policy (2017).

tive Investment (around 13%). In terms of geographical distribution, New Member States require a much higher contribution (60%) compared to EU15 countries which require only 30% of the total expected investment.

Tables 3 and 4 present summary statistics for investment costs, FRR, ERR at country and sector levels. The total amount of investment costs is about €180 billion whilst the average investment cost is €190 million with a large standard deviation among countries and sectors. For example, the average investment cost in the Czech Republic is about seven times higher compared to Malta (Table 3) whilst the average investment in the transport sector is more than three times higher compared to the health sector[23] (Table 4).

In terms of sector share of investments at the country level, calculated as the ratio between total investment in each country out of total investment for each sector in the considered country, transport and environment projects have the largest share, both in EU15 and New Member States.

With respect to FRR the average value is −2.9% with a standard deviation of 6.3. As already observed by Florio and Vignetti (2005) a negative FRR is not

23 This is hardly surprising as transport projects are usually the largest investments: 17 of 18 major projects with total cost over €1 billion are transport projects. In order to adjust their long implementation timetables to the relatively shorter EU funds programming period, these projects are often sliced into subprojects, while CBA is still undertaken on the entire project.

Table 3 Investment and returns by country.

Country	Investment costs (millions of euros)			Financial rate of return (%)			Economic rate of return (%)		
	Mean	St. dev.	Median	Mean	St. dev.	Median	Mean	St. dev.	Median
Czech Republic	389.0	476.0	150.0	−1.7	4.3	−1.8	10.1	7.3	7.3
Greece	339.0	472.0	121.0	−2.2	5.5	−1.6	16.7	15.5	11.1
Germany	318.0	296.0	201.0	−1.6	4.7	−3.4	21.5	15.8	16.1
France	234.0	325.0	108.0	−0.7	5.4	0.0	15.9	15.1	11.7
Italy	232.0	274.0	140.0	−5.7	8.4	−4.0	24.5	23.8	16.7
Hungary	193.0	210.0	110.0	−4.0	3.3	−3.4	12.3	8.4	9.2
Spain	188.0	234.0	114.0	−0.5	5.6	−0.6	13.7	11.5	8.7
Slovakia	165.0	136.0	123.0	−3.6	3.8	−3.1	13.7	8.4	11.0
Poland	157.0	207.0	84.1	−1.9	7.1	−0.5	16.5	11.8	13.4
Portugal	155.0	165.0	89.4	−1.0	5.9	−1.8	16.0	13.0	10.4
Bulgaria	144.0	103.0	97.1	−7.4	11.5	−3.9	15.9	9.5	11.3
Romania	136.0	208.0	84.5	−5.5	4.6	−5.5	17.9	7.9	16.8
Ireland	109.0	56.9	82.9	5.0	.	5.0	11.1	1.6	12.0
Slovenia	103.0	89.2	91.8	−2.0	4.2	−1.4	12.2	4.5	11.1
Cyprus	92.6	23.8	95.0	−4.3	.	−4.3	10.6	1.7	10.8
United Kingdom	90.1	53.5	63.1	−2.4	5.9	−1.1	24.9	19.3	24.8
Latvia	91.2	53.2	80.8	−3.1	3.2	−2.6	16.3	9.9	14.7
Croatia	80.1	71.9	46.2	−4.2	1.8	−4.1	12.0	3.7	11.7
Estonia	76.7	38.6	68.6	−0.9	4.0	−1.3	15.8	7.5	12.8
Lithuania	67.4	28.9	60.5	−11.8	7.9	−10.7	13.9	7.1	10.6
Austria	56.5	29.0	56.5	1.1	5.2	1.1	12.4	.	12.4
Malta	54.4	9.6	52.0	−2.8	2.8	−3.2	13.3	6.8	11.3
New Member States	171.0	242.0	86.6	−3.4	6.3	−3.0	15.2	10.0	12.2
EU15	228.0	301.0	115.0	−1.8	6.3	−1.6	18.3	17.1	11.8
Total	190.0	263.0	93.6	−2.9	6.3	−2.7	16.2	12.8	12.0

Source: Own elaboration on data provided by Directorate General for Regional and Urban Policy (2017).

surprising as these projects usually have low financial returns and for this reason they need support by the EU. For example, Table 3 shows how the average FRR in Lithuania is −11.8% meaning that, in this country, projects are likely to be much more in need of financial assistance compared to the EU15 average (−1.8%). At industry level, sectors with closer exposure to market are, not surprisingly, reporting positive FRRs, such as productive investment (6.6%) and energy infrastructures

Table 4 Investment and returns by sector.

	Investment Costs (millions of Euros)			Financial Rate of Return (%)			Economic Rate of Return (%)		
	Mean	**Standard dev.**	**Median**	**Mean**	**Standard dev.**	**Median**	**Mean**	**Standard dev.**	**Median**
Transport	**279.0**	**337.0**	**146.0**	**−3.9**	**6.0**	**−3.0**	**14.4**	**10.3**	**11.1**
Road and Motorways	319.0	358.0	174.0	−4.3	6.2	−3.7	16.5	10.4	14.0
Railways	352.0	390.0	206.0	−3.9	5.3	−3.2	10.7	8.3	8.9
Other Transport	159.0	195.0	92.5	−3.5	6.3	−2.3	15.3	10.9	12.1
Environment & Environmental infrastructure	**84.1**	**71.9**	**65.9**	**−3.7**	**4.5**	**−3.5**	**14.7**	**8.9**	**11.9**
Management and distribution of water	95.2	95.3	71.5	−3.3	3.4	−3.7	14.2	9.3	11.7
Management of household and industrial waste	76.9	51.2	51.7	−4.6	6.2	−3.5	14.2	6.4	12.4
Other environmental services	75.1	42.0	63.7	−3.7	4.7	−3.1	15.3	9.3	11.9
Research and development and innovation	**114.0**	**68.0**	**99.8**	**0.7**	**9.1**	**3.0**	**21.1**	**18.0**	**13.8**
Energy infrastructure	**141.0**	**143.0**	**75.4**	**3.5**	**3.4**	**2.0**	**16.0**	**7.5**	**14.1**
Information and communication technology (ICT)	**96.3**	**58.4**	**77.8**	**−6.4**	**7.9**	**−6.0**	**33.8**	**27.5**	**20.6**
Productive investment	**161.0**	**144.0**	**120.0**	**6.6**	**4.7**	**6.0**	**28.0**	**17.6**	**28.0**
Health infrastructure	**82.5**	**38.3**	**66.8**	**−1.6**	**5.9**	**−3.4**	**18.5**	**18.4**	**11.7**
Others	**79.4**	**44.0**	**66.9**	**−4.7**	**5.3**	**−3.0**	**17.6**	**17.0**	**11.0**
Total	**190.0**	**263.0**	**93.6**	**−2.9**	**6.3**	**−2.7**	**16.2**	**12.8**	**12.0**

Source: Own elaboration on data provided by Directorate General for Regional and Urban Policy (2017).

(3.5%). One sector which does not follow this pattern is ICT (−6.4%) and this can be explained by robust application of State Aid rules, as investments are often concentrated in rural and peripheral areas, with evident market failure in terms of broadband services.[24]

Finally looking at the ERR, the average value is 16.2% with the highest return in the United Kingdom (24.9%), Italy (24.5%) and Germany (21.5%) and the lowest in Czech Republic (10.1%). This result suggests that economic benefits of these projects are higher in EU15 compared to New Member States; this could be partially explained by sector composition effect and the relatively small number of projects in the EU15. In fact, the proportion of projects in traditional infrastructure which presents a lower ERR is much higher in New Member States than in EU15 (for example, transport projects present lower ERR (14.4%) compared to other sectors such as ICT (33.8%)).

From summary statistics in Tables 3 and 4, it is also possible to notice that the standard deviation of ERR (12.8%) is much higher of the FRR (6.3%). According to Florio and Vignetti (2005) on the analysis of 240 projects in 11 ISPA countries, the high variability of FRR and ERR is not just driven by countries or sectors specificities but it depends also on project-specific characteristics as well as possible inconsistencies in applying the principles of CBA across different teams of experts preparing applications. It may be a safe assumption that certain inconsistencies continued during the 2007–2013 period, especially between countries assisted and not assisted by JASPERS which reviewed applications and CBAs for over 500 major projects in countries that accessed the EU after 2003.

We want to address two main questions: to what extent has the CBA introduced corrections to the financial analysis? What are the main drivers of such corrections? Whilst only a project by project review could provide detailed information about the way in which shadow prices, externalities and other nonmarket effects have been considered in the project appraisal, we are interested here to see the aggregate effect of CBA in respect to a financial appraisal.

While we cannot observe market and shadow prices in our data, inspection of the project applications suggests that these vary across industries and countries. For example, the marginal social value of time savings in transport projects is correlated to users' income which widely differs across Member States (Bickel et al., 2006). Shadow wages, as previously explained, should be correlated to regional unemployment and specific labor market regimes. Moreover, the extent of externalities is certainly different across diverse industries. In order to address this variability we turn to a simple regression analysis in the next Section. However, before

24 Some projects concerned only backbone networks while "last mile" is left to market players, and this also has implications on the lower profitability of projects.

presenting our analysis, it may be interesting to mention some examples of these project applications to provide an intuition of the CBA role in this context. For example, in the road transport sector, projects with the highest economic impact are typically ring roads of cities that divert heavy traffic from the congested existing roads; these projects allow high savings in value of time, vehicle operating costs and show high environmental benefits. Moreover the more developed and congested is the region (and the city) in which this type of project is located, the better is their economic viability. For instance, the internal ring road of Wroclaw (Poland, Dolnoslaskie) achieves impressive ERR (68%); whereas in smaller cities, construction of ring roads on national roads brings smaller yet impressive returns: ring road of Serock (Mazowieckie) (37%), Jedrzejow (Swietokrzyskie) (31%), whereas sections in Eastern Polish regions score much lower: Jaroslaw (Podkarpackie) (15%), Hrubieszow (10%) and Barglow (Podlaskie) (6%). At the same time, all these roads are toll-free so the financial analysis is generally negative. The same pattern can be found in other countries such as Spain where the most economically viable project is the new eastern ring road of Malaga (46% ERR), whilst national motorways score much worse because of more limited traffic.

Productive investments analyzes are indeed a place for applicants to maneuver between financial and economic viabilities (e.g., certain UK technology transfer center has 6% of FRR while 38% of ERR). A productive investment in France has FRR of 13% while ERR of 30%. There are also productive investments with good financial scores while bringing less for society: one application in Poland has an impressive FRR of 38%, while ERR was less impressive (nearly 17%). Another productive investment in Spain has FRR of 60% while ERR is only 21%. Some projects were not approved because their FRR suggested they do not need financial assistance by the EU or they did not provide sufficient explanation of incentive effect in the region.

5 Results

The following Equation (6) is used as an empirical benchmark model to test the predictive power of financial returns on economic returns, after controlling for some project characteristics:

$$\mathrm{err}_i = \beta_0 + \beta_1 \mathrm{frr}_i + \beta_2 \mathrm{time\_horizon}_i + \beta_3 \mathrm{lninv}_i + \beta_4 \mathrm{sector}_i + \beta_5 \mathrm{country}_i + u_i, \tag{6}$$

where, err and frr are, respectively, the economic and financial rates of return of a major project i. The remaining covariates are controls: time_horizon represents the temporal horizon used for CBA analysis; lninv is the natural logarithm of the investment cost, sector and country are dummy variables to control for composition effects that may arise from sector heterogeneity and geographical location of the project, and u_i is the error term.

We estimate an ordinary least squares (OLS) regression. Table 5 shows the first set of results. Columns (1) and (2) consider ERR as dependent variable whilst FRR, investment cost and time horizon are the regressors; operating sectors and country dummies (in column 2 only) are additional controls; Column (3) disregards individual country dummies while it includes a simple dummy for EU15 and New Member States. Columns (4)–(6) add the natural logarithm of the average real GDP per capita at PPP in the period 2007–2013 for each country in which the project is located as an additional control.

In all these specifications the coefficient of frr is positive and significant. This suggests the existence of a positive correlation between projects which are marginally favorable from a commercial point of view and those which are also worthy for the society. The fact, that FRR is a predictor of ERR suggests that, on average, bad projects in financial terms are not *per se* particularly good in economic terms.[25] This result may also be useful to stress the value of combining a financial and an economic analysis as proposed by the CBA Guide for a fairer allocation of the grants. In fact, applicants who tend to underestimate their financial revenues to maximize the expected grant risk to present economic benefits that are too low and will therefore have fewer chances to receive the grant.

The coefficient of time horizon used to discount cash flows is significant and negative in all specifications suggesting that when benefits are spread over a long period the impact on the ERR is negative, after controlling for the other variables. The coefficient of total investment cost is also negative and significant in all specifications. In fact, the ERR by construction is not an absolute indicator as it is the ENPV, and while it is likely that bigger projects in terms of investment cost have higher ENPVs compared to the smaller ones, in relative terms these may be less efficient.

The coefficients for sectors show the importance of the composition effect, confirming that even after considering the FRR, the aggregate ERR is influenced by the portfolio composition in terms of type of the investment supported. In this respect it seems that projects in ICT, road and motorways, and productive investment are relatively more socially efficient than projects in energy infrastructure, used a benchmark. This suggests that after controlling for projects' scale and duration, CBA captures some sector specificities in terms of externalities and shadow

25 This statement mainly refers to projects delivering goods/services captured by market forces. Obviously this does not cover projects where there was a policy decision on absence of tariffs, for example, ring roads of cities to displace traffic from the city centers.

Table 5 The relation between ERR and FRR of major investment projects (2007–2013).

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	err	**err**	**err**	**err**	**err**	**err**
frr	0.156*	0.261***	0.155*	0.164*	0.261***	0.181**
	(0.0864)	(0.0896)	(0.0866)	(0.0882)	(0.0896)	(0.0883)
time_horizon	−0.341***	−0.279***	−0.343***	−0.333***	−0.279***	−0.336***
	(0.0991)	(0.0977)	(0.0994)	(0.0999)	(0.0977)	(0.1000)
lninv	−1.297***	−1.357**	−1.333***	−1.220**	−1.357**	−1.348***
	(0.493)	(0.534)	(0.511)	(0.497)	(0.534)	(0.509)
Transport						
Road and Motorways	3.869**	5.018**	3.925**	3.894**	5.018**	4.428**
	(1.892)	(2.164)	(1.917)	(1.880)	(2.164)	(1.957)
Railways	−1.981	−0.883	−1.930	−1.888	−0.883	−1.229
	(1.771)	(1.995)	(1.791)	(1.762)	(1.995)	(1.832)
Other Transport	2.004	2.850	1.962	2.142	2.850	2.111
	(1.916)	(2.087)	(1.945)	(1.922)	(2.087)	(1.955)
Environment						
Management and distribution of water	0.0476	0.0886	0.0773	−0.0924	0.0886	−0.165
	(1.788)	(1.916)	(1.802)	(1.786)	(1.916)	(1.812)
Management of household and industrial waste	−0.640	−0.625	−0.583	−0.809	−0.625	−0.717
	(1.949)	(2.165)	(1.961)	(1.941)	(2.165)	(1.958)
Other environmental services	0.616	2.172	0.623	0.706	2.172	0.983
	(1.846)	(1.952)	(1.854)	(1.833)	(1.952)	(1.858)
Other Sectors						
Research and development and innovation	3.350	4.547	3.362	3.440	4.547	3.749
	(3.205)	(3.224)	(3.210)	(3.211)	(3.224)	(3.236)
Information and communication technology	18.13***	17.86***	18.02***	18.49***	17.86***	18.42***
	(5.488)	(4.963)	(5.453)	(5.479)	(4.963)	(5.477)

Continued on next page.

Table 5 (Continued).

Productive investment	7.254**	11.67***	7.027*	7.737**	11.67***	6.920*
	(3.659)	(3.765)	(3.723)	(3.680)	(3.765)	(3.772)
Health infrastructure	−1.717	−0.209	−1.745	−1.550	−0.209	−1.402
	(2.593)	(2.736)	(2.603)	(2.600)	(2.736)	(2.628)
Others	−3.500	−3.397	−3.555	−3.235	−3.397	−3.093
	(2.690)	(2.550)	(2.679)	(2.726)	(2.550)	(2.706)
Country	—	YES	—	—	YES	—
New Member States	—	—	−0.304	—	—	−2.607*
			(1.003)			(1.368)
gdp_per head	—	—	—	−1.567	3.481	−5.220**
				(1.784)	(5.396)	(2.414)
Constant	47.76***	48.97***	48.69***	61.49***	16.43	101.5***
	(8.993)	(9.856)	(9.592)	(18.16)	(52.27)	(26.31)
Observations	762	762	762	762	762	762
R-squared	0.204	0.287	0.204	0.205	0.287	0.208

Robust standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Omitted Sector: Energy Infrastructure.

prices. For example, as seen in Table 4, the average FRR in the road and motorways sector is negative; this possibly reflects the fact that road tolls are either nonexistent or inferior to the recovering costs, therefore these projects, on average, are not favorable from a financial point of view; conversely benefits for users expressed in terms of marginal social value of time savings and other typical ingredients of road infrastructures lead to high ERR showing that these projects are beneficial for the community. With respect to ICT, low FRRs are probably due to the high costs and modest revenues of broadband investments in rural and peripheral areas, whilst a particularly high ERR, reflects the social value of bridging the digital divide, consistently with the EU objectives in this matter. In contrast, energy project (the omitted benchmark sector in the analysis), possibly due to the liberalization of the industry in the EU and the consequent increase of tariffs, shows a positive FRR and while the ERR is higher, the spread is inferior to the spreads of roads, ICT, environment, and R&D. The wide gap between FRR and ERR in the case of productive investment (usually manufacturing) is more difficult to explain. The average FRR, as expected, is the highest across sectors, but its spread ERR–FRR is also high (Table 4). One reason could be that applicants in this sector make optimistic assumptions in estimating benefits (in order to justify the grants although this was not always a successful strategy[26]); another possible reason could be related to the use of shadow wages. In fact, most of these projects are implemented in Spain (45%), Portugal (32%) and Greece (6%) where unemployment rates are high. Hence it is also plausible that by using low shadow wages to account for unemployment in Southern Europe, this sector shows a higher ERR.

While results for productive investment may be correlated to optimistic assumption of applicants or to the location of such projects in high unemployment regions, it is interesting that findings for ICT and roads are consistent with previous empirical results by Del Bo, Florio and Manzi (2010), Del Bo and Florio (2012) and based on an entirely different approach and set of data. In this earlier literature a correlation between growth and the endowment of infrastructure is studied by empirically estimating an aggregate production function in a spatial econometrics context, using EU data at regional level. The main finding is that GDP growth is more strongly correlated to the availability of telecommunication and transport infrastructure. The fact that the same sectors emerge from a project-level analysis as particularly correlated to the spread between economic and financial returns seems interesting and is worthy of further research, where data at country/region and project level are compared more in-depth. In fact this is also consistent with other studies that highlight the strong socio-economic impact of EU funds when implementing large ICT infrastructure in peripheral areas (Catalano & Florio, 2017).

In columns (4) and (5), it is also worth noting that when introducing both country dummies and GDP per capita we do not find any effect for GDP; however when controlling for New Member States versus EU15 countries in column (6) the effect becomes significant and negative. This indicates, as expected, that all being equal, countries with lower GDP per capita should be able to obtain higher social benefits from the project implementation. However the negative and significant coefficient for New Member States, compared to EU15, indicates that despite this catching up effect in terms of GDP, New Member States are still not capable of pushing their ERR compared to FRR, maybe because of lack of institutional capacity or skills in applying CBA techniques.

In order to further investigate the sector effect we group all sectors into three main categories (i) Transport; (ii) Environment and (iii) All other sectors, including R&D, ICT, health infrastructure and so on. Results are shown in Table 6, columns (1)–(3). In column (1) it is worth noting that, all other things being equal, projects in environment have a lower ERR compared to other sectors (used as the benchmark). This result could possibly highlight the difficulties for CBA of environmen-

26 The Commission issued four negative decisions refusing EU grants for productive investments and other projects were withdrawn, due to their low innovative profile, poor incentive effect, and not convincing benefits for the regional development.

Table 6 The relation between ERR and FRR of major investment projects (2007–2013).

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
	err	**err**	**err**	**err**	**err**	**err**
frr	0.208***	0.194**	0.194**	0.227***	0.215***	0.215***
	(0.0796)	(0.0788)	(0.0788)	(0.0814)	(0.0803)	(0.0803)
time_horizon	−0.481***	−0.459***	−0.459***	−0.580***	−0.554***	−0.554***
	(0.0943)	(0.0932)	(0.0932)	(0.0817)	(0.0799)	(0.0799)
lninv	−1.441***	1.979	1.979	−1.254**	−2.289***	−2.289***
	(0.513)	(2.324)	(2.324)	(0.511)	(0.534)	(0.534)
transport	−1.668	78.11*	78.11*	—	—	—
	(1.736)	(43.81)	(43.81)			
environment	−3.288**	40.87	40.87	—	—	—
	(1.654)	(44.93)	(44.93)			
othersectors	—	—	—	—	—	—
lninv*transport	—	−4.329*	−4.329*	—	—	—
		(2.380)	(2.380)			
lninv*environment	—	−2.397	−2.397	—	—	—
		(2.453)	(2.453)			
lninv*othersectors	—	—	—	—	—	—
transport	—	—	—	—	—	—
othersectors2	—	—	—	−0.558	−60.72***	−60.72***
				(1.029)	(21.81)	(21.81)
lninv*transport	—	—	—	—	—	—
lninv*othersectors2	—	—	—		3.277***	3.277***
					(1.189)	(1.189)
gdp_per head	—	—	−7.026***	—	—	−6.900***
			(1.945)			(1.964)
Country	YES	YES	YES	YES	YES	YES
Constant	60.30***	−3.120	62.56	57.81***	76.50***	141.0***
	(9.502)	(42.99)	(47.70)	(9.954)	(10.36)	(24.27)
Observations	762	762	762	762	762	762
R-squared	0.207	0.215	0.215	0.203	0.211	0.211

Robust standard errors in parentheses ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. *Notes:* (1)(2)(3) Omitted Sector: Other Sectors (5)(6)(7) Omitted Sector: Other Sectors 2 = Other Sectors + Environment.

tal projects in showing their economic benefits compared to their financial returns whilst compared to other sectors. In columns (2) and (3) when including interactions between investment and these three groups of sector dummies we notice that transport is the sector which shows higher economic benefits compared to the financial ones, after controlling for investment costs. Finally, in columns (4)–(6) as an additional robustness check, we group sectors into two main groups (1) transport and (2) all other sectors including the category environment. Results confirm again that projects in transport have higher ERR compared to all other sectors, all things being equal.

6 Concluding remarks

This paper contributes to the literature on CBA practice in three different ways. *First* it highlights the development of the CBA approach, from the first edition of the EC Guide in 1994 to the current one (2014), in response to the changing EU regional policy. In this context, CBA has been instrumental in creating a common evaluation framework among 28 Member States of the EU, in spite of considerable variability of national socio-economic conditions, institutional capacity, administrative and legal specificities. The evolution of the role of CBA for major projects appraisal under the EU Structural Funds, from an initially timid approach to a mandatory framework shows, at the same time, its flexibility and success in increasing the homogeneity in evaluation mechanisms. In fact, the EC Guide has developed consistently over its five editions through an increasing number of case studies and technical refinements. We suggest that the Guide represents a true European intellectual project and shows the value added of adopting a common project evaluation framework in regional policy in an otherwise highly fragmented panorama.

Second, we discuss a specific distinctive feature of the CBA Guide approach, which is common to all the five editions: the requirement that applications for funding must integrate the financial and economic analyses of projects. While this approach is not new, it is relatively unusual as a systematic screening mechanism. For example, most CBA manuals and operative procedures in public administration tend to focus exclusively on economic appraisal (Boardman et al., 2001; De Rus, 2010; Warner, 2010). However, there is an important advantage in the integration of these two perspectives; optimism bias in economic appraisal may lead to a self-defeating strategy of presenting projects with high financial returns, which usually may not be funded under the current EU Cohesion Policy regulations. On the other side, in public investment policies more emphasis is given to capital expenditure, while operational expenditure tends to be downplayed; in this context the important role of the financial analysis is to ensure that investment projects are financially sustainable (do not run out of cash in the reference period) while offering goods and services that are not captured by market prices.

Optimism bias and incentives for applicants to exaggerate benefits and underestimate costs are a constant feature of project evaluation, see the discussion of these issues by Florio (2007), De Rus and Socorro (2010), Flyvbjerg (2013). It is not easy to contain this bias. In the case of the EU regional policy project applications are reviewed by various institutions: the EC, JASPERS, the European Investment Bank, and also by external consultants. This initial screening counteracts to a certain extent the problem. Moreover, while not in a systematic way, *ex post* evaluation of major projects has been launched by the EC and is ongoing (Kelly et al., 2015). The way in which the co-funding mechanism by the EU is now designed, as described in Section 3 (Equation (2)), somehow constrains the optimism bias in terms of costs and revenues against the amount of the grant that can be obtained.

Third, taking advantage of the above-mentioned feature, we analyze the relationship between the economic and financial rates of return of a large sample of projects as a statistical proxy of the role of CBA in correcting market prices by shadow prices and in including externalities. After controlling in simple empirical models for project scale, duration, and country fixed effects, there are two main findings. Financial and economic returns are positively correlated, showing that, on average, proposed projects, which are expected to be beneficial for the society, are not the most loss makers, although these would have not been financed by private investors. In other words, the CBA captures the expected socio-economic impact of the project by shifting its profitability after the EU grants, but this does not imply that CBA gives an advantage to the worst projects in financial terms (which would be the case if the FRR–ERR correlation were negative). Second, there is variability across sectors of such result.

Further research is needed to understand the determinants of the positive correlation between economic and financial returns that we have detected. In the framework of Equation (5) this calls for a fine grain analysis of the correlation between shadow prices and observed prices, including the issue of how externalities have been included in the analysis. In this perspective, it is interesting that the ERR compared to FRR is higher in some sectors, such as roads, ICT and productive investment. This suggests that on one side, sectors actually differ in terms of the extent of externalities and other market failures, after controlling for costs and duration, but on the other side it may be the case that CBA is still applied in different ways, according to different traditions and assumptions across sectors. Roads are a clear example, given the difference between modest-toll or no-toll policy, on one side, and the marginal social value of saving time for users on the other side. It is widely recognized that CBA is most advanced and established in the transport sector, and this allows to better account for nonmarket effects. The CBA practice in the environment sector is more recent compared with transport. For example, the health benefits of solid waste management and of water treatment may have not been estimated as an externality, beyond the WTP for the service, or its price. ICT seems to be an example of a low FRR, probably because of the high costs of broadband investment in rural or peripheral areas, and a particularly high ERR, reflecting the social value of bridging the digital divide, consistently with the EU objectives in this area.

Another issue left for further research is the difference across sectors of the time horizon of the analysis (the EC Guide suggests from a minimum of 10 years to a maximum of 30 years depending on the sector of intervention) but it should be interesting to observe project by project what time horizon was assumed for the appraisal. Intersectoral comparisons of ERRs are also affected by the legal framework that requires projects to present ERR higher than the SDR, but there is no legal requirement to maximize the ERR in the overall investment portfolio. In this perspective, further research should study clusters of projects by sector and countries to detect more in-depth the drivers of the divergence between market and shadow prices, for instance looking at samples of road projects in different countries and so on.

Finally, in this paper we have not discussed the evidence arising from the *ex post* evaluation of the approved projects. As mentioned some of the projects in our sample may have been withdrawn, modified or have experienced delays, even if the large majority have been eventually approved. Retrospective evaluation on small samples is available, and it would be interesting to study more systematically the relation between *ex ante* and *ex post* CBA, as suggested by Boardman, Mallery and Vining (1994), Florio (2014), and Kelly et al. (2015).

Appendix. Project applications by country and sector (2007–2013)

	Road and motorways	Other transport	Rails	Management and distribution of water	Other environmental services	Management of household and industrial waste	R&D and innovation	Energy infrastructure	Information and communication technology (ICT)	Productive investment	Health infrastructure	Others	Tot.
Poland	12	33	19	26	21	5	27	24	11			7	185
Romania	18	3	5	42	8	17			1				94
Spain	4	14	4	19	9	1	2			14			67
Czech Republic	20	2	26	1	8	2	1						60
Hungary	9	3	4	2	12	2	2				8	1	43
Greece	11	12		1	3			7	4	2	2		42
Italy	2	11	9	2	4		1	2	6		2	1	40
Portugal	2	6	6	5	5	1			1	10	2	1	39
Slovakia	16	4	5	4	7								36
France	1	12	4	1	3	1	2	1	5	1	2	1	34
Bulgaria	6	8	3	6	2	1							26
Germany	11	3	6		1			1		3		1	26
Estonia	3	1		3	2						3		12
Slovenia	3	1	3	1	2	1	1						12
United Kingdom		1			1		4	1	3			2	12
Latvia	2	3	2	1	1						1		10
Croatia		1	1	1	3	2							8
Lithuania	2		3		1		2						8
Malta	1				2	1					1		5
Austria										1			1
Cyprus	1												1
Ireland			1										1
Tot.	124	118	101	115	95	34	42	36	31	31	21	14	762

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The economic value of the recreational red abalone fishery in northern California

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There is a long tradition of recreational red abalone (*Haliotis rufescens*) fishing in northern California. The fishery is enjoyed by tens of thousands of fishers along Sonoma and Mendocino counties, but little is known about its economic value. Recreational fisheries are difficult to value because the catch is not sold commercially and the activity is dispersed along the coastline. For this study, we estimated the value to the fishers of the recreational red abalone fishery using the travel-cost estimation method, a non-market valuation approach. Using data for the 2013 season at more than 50 sites, we find that approximately 31,000 fishers derived between \$24M and \$44M per year of recreational value from the fishery. The lower figure was estimated based solely on fishers' driving costs, while the larger estimate results when also considering the time fishers spent on the activity. Examination of site-level variables influencing the choice made by fishers among the sites shows that key site selection criteria included 1) impacts of a harmful algal bloom in Sonoma County, 2) protection from northwest ocean swell, and 3) presence of amenities such as boat launches and restrooms. We show that the value of the fishery declined nearly \$12M after stricter regulations were imposed in 2014 following a harmful algal bloom that killed thousands of abalone in Sonoma County. The economic value of the fishery clearly warrants investment in both the biological and economic sustainability of this important resource.

Key words: Economic Impact, *Haliotis rufescens*, Non-Market Value, Socioeconomics, Sport fisheries, Travel Cost Method

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California has the largest ocean economy in the United States with a gross state product of nearly $42B estimated for the year 2000 (Kildow and Colgan 2005). Recreational fishing is the third most popular water related activity after beach going and swimming. More than 2.7M people enjoy recreational ocean fishing annually in California (Leeworthy 2001). In California, it is estimated that recreational fishing generates an estimated $230M-$610M in direct expenditures per year (2010) (Pendleton and Rooke 2006). Estimates of the total non-market use value of recreational fishing is much higher and ranges between $342M -$2B for the year 2010 (Pendleton and Rooke 2006). As California grows in population, the number of people that participate in recreational fisheries is forecast to increase by 12% per decade (Leeworthy 2001) putting greater pressure on marine resources. Despite the importance of recreational fishing, estimates of market (money anglers contribute through spending) and non-market values (value fishers place on the resources they use) for individual recreational fisheries are scarce.

Red abalone (*Haliotis rufescens*) forms the basis for a recreational fishery in northern California yet little is known about the magnitude of its economic importance. Approximately 35,000 fishers (2000-2014), take 245,000 red abalone (2002-2014) per year (California Department of Fish and Wildlife [CDFW] unpublished data). The majority of the catch (95%) comes from Sonoma and Mendocino counties (Kashiwada and Taniguchi 2007). The recreational red abalone fishery in northern California is the only abalone fishery remaining open in the state. In 1997, commercial fishing was closed statewide and recreational fisheries for abalone were closed south of San Francisco due to declines in stocks (Karpov et al. 2000). The north coast fishery has been restricted to recreational users since 1949 and permits skin (breath-hold) diving only. The fishery is managed for sustainability under the Abalone Recovery and Management Plan (CDFW 2005), which aims to maintain abalone population densities to ensure productivity and consequently the economic viability of the fishery. The Marine Life Management Act (MLMA 1999) supports the management of California's fisheries to sustain, conserve and protect California's marine life including those with economic value.

Despite the recreational, cultural and economic importance of the red abalone fishery, little work has been done to estimate its economic value. Valuation of recreational fisheries is difficult since it is illegal to sell recreationally caught red abalone (aka illegal commercialization) in California (Rogers-Bennett and Melvin 2007). Commercial fisheries, on the other hand, are more easily valued by calculating income from ex-vessel landings. In this paper, the non-market economic value of the recreational red abalone fishery to the fishers, is estimated using the travel-cost method. The relative importance of site attributes at more than 50 sites is examined to determine site qualities used in site selection and the potential losses from a site closure. The non-market value of the fishery is estimated for eight years from 2003 to 2014. The gender and age of the fishery questionnaire respondents is reported to give an indication of demographics in this fishery. Finally, the economic value of the fishery is examined in light of prioritizing funding needs to sustain both the fishery and its economic benefits.

Materials And Methods

The travel-cost method (TCM) (Phaneuf and Smith 2005) is an economic approach used to assign monetary value to non-market goods such as recreational activities or resources. The model's premise is that travel costs are a proxy for the value of unpriced recreational sites, and that people for whom travel costs are lower will visit a site more frequently, mirroring the basic relationship between price and quantity demanded for normal goods. The TCM takes into account the various costs paid by a participant to engage in the activity. These include direct costs such as fees, and other costs such as the opportunity cost of time and vehicle operating costs. Using this information, a travel cost function and demand curve (Figure 1) can be estimated where the consumer surplus is representative of the economic value of the resource to the recreational users. Parsons (2003) provides a detailed overview of the method.

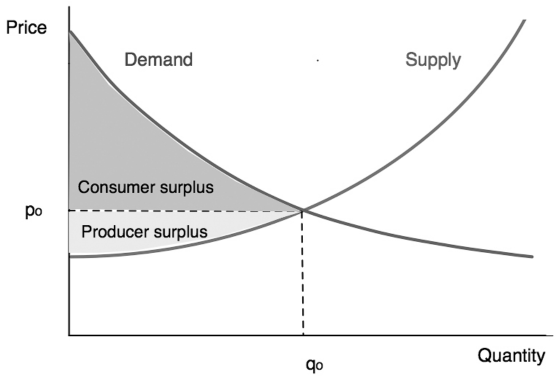

Figure 1. - Demand curve showing the marginal willingness to pay (WTP), with the area under the curve representing the total WTP.

Travel-cost studies follow one of two basic approaches: single-site models and multi-site models. Single-site models construct a demand curve based on the relationship between the cost of visiting a site and the frequency of visits. Multi-site models add in the element of choice from among a set of alternative sites for the same recreational purpose, and isolate the impact of site characteristics on the choice of sites, while also estimating the overall value of recreation. Given that abalone is taken at more than 50 different sites along the coast, a multi-site model was adopted for this study.

Data were drawn from the 2013 season CDFW database of 30,768 abalone report card holders, which represents the population of licensed harvesters, and a telephone survey of a random sample of this population. CDFW conducted the telephone survey of this group in 2014, with 516 responses regarding the 2013 fishing season. Information on the response rate to the telephone survey was unavailable. Respondents to the telephone survey provided demographic information and data on their fishing histories and habits. Of these 516 respondents, 392 also provided detailed catch information (which is not collected in the telephone survey) to the CDFW via its reporting system. Because we had both demographic and catch data from these 392 respondents, they were used as our sample for the travel-cost analysis.[1]

1 A representative sample (*n*) size is commonly obtained by solving $n=(Z^2pq)/e^2$ where *n* is sample size, *Z* is the value obtained from a normal curve at the desired confidence level (95%), e is the desired level of A representative sample *(n)* size is commonly obtained by solving $n=(Z^2 pq)/e^2$ where *n* is sample size, *Z* is the value obtained from a normal curve at the desired confidence level (95%), *e* is the desired level of precision, *p* is the estimated proportion of an attribute that is present in the population, and *q* is *1-p*. A conservative approach assumes the maximum variance implying $p = q = 0.5$ with a confidence interval of 95% and a maximum sample error of 5%, then the optimal sample is 385 observations. Furthermore, the unit of analysis here is recreational trips and 392 individuals account for 1,520 trips.

There is a risk that this group is not representative of the overall population; those reporting may collect more or less than the average number of abalone, prefer certain kinds of sites, be demographically distinct or in some other relevant way diverge from the population. We do not have any information to indicate specific ways in which our sample may differ from the population at large.

In order to construct a database of trips, the unit of analysis in a travel-cost study, we examined respondents' reported abalone catch by date and fishing site from the report card database and cross-referenced the information with the number of trips they reported in the telephone survey. Analysis was performed on the resulting 1,537 trips.

The site attributes were chosen based on consultation with CDFW staff experts. Attributes selected were those perceived to impact where fishers choose to fish, to vary across sites and for which information exists for all sites. Some attributes found to be important in previous research, such as abundance and size (Chen et al. 2013), have not been measured systematically for all 51 sites (or even a significant subset of the most important sites), so we could not compare sites with respect to those variables. The two most important variables studied by Chen et al. (2013) and in this study were the ease of access to the water and the protection of sites from swells. While most of the site attributes (Table 1) were specific to that site and independent of neighboring sites (e.g., parking, bathroom facilities), two of the attributes influenced multiple neighboring sites. Protection from wave exposure by a headland may influence the number of days of accessibility to a number of neighboring sites. Also, a harmful algal bloom (HAB) in 2011 caused significant declines in abalone density within all of the Sonoma County area sites (Porzio 2014).

Table 1.—Site characteristics used for travel-cost analysis

Attributes	Variable name	Description	Type
Access	ACC	Difficulty of access to the water from parking area, often determined by steep terrain.	Category: 1-3 1 = easy, safe access 3 = most difficult or dangerous access
Boat launch	BL	Existence of a boat launch.	Dichotomous: 0 = no 1 = yes
Parking	Parking	The availability of parking.	Category: 1-3 1 = abundant parking 3 = very limited parking
Bathrooms	Bath	Existence of public bathrooms.	Dichotomous: 0 = no 1 = yes
Exposure to ocean swell	PROTEC	The degree of protection afforded by geographic features to prevailing NW swells.	Category: 1-3 1 = least exposed 3 = most exposed
Harmful algae bloom	HAB	Site affected by 2011 harmful algae bloom.	Dichotomous: 0 = no 1 = yes
Pay for parking	PAY	Whether parking requires payment of a fee.	Dichotomous: 0 = no 1 = yes

We assume that the welfare obtained by an individual *i* from a trip to the site *j* on decision occasion *t* is given by the following utility function:

$$U_{ijt} = \beta_1\, TC_{ij} + \beta_2\, ACC_j + \beta_3\, BL_j + \beta_4\, Parking_j + \beta_5\, Bath_j + \beta_6\, PROTEC_j + \beta_7\, HAB_j + \beta_8\, PAY_j + \mu_{ijt}$$

In this equation TC*ij* is the travel cost from each *i*-th individual´s origin to the destination *j*. Travel cost includes the cost of operating a vehicle, for which we used the federally specified rate of $0.565 per mile for 2013. Distances and travel times were calculated with Google Maps (V2), using respondents' home zip code as trip origin and the coordinates of the abalone site visited as the destination. To this we added the opportunity cost of time traveling and spent at the recreation site. Common practice (Cesario 1976; Parson 2003) is to use a fraction, which we set at 0.5, of the person's wage. We encountered a gap in the data because many of the respondents to the telephone survey declined to provide income information and no income data is contained in the report card database. The model was therefore estimated with two variants on the definition of travel cost. For those respondents without income data, we used the average income for their zip code of residence. We ran one regression using only the driving cost (TC1) in order to use the whole sample with consistent data for every trip. This approach underestimates the travel cost and, consequently, recreational value, representing therefore a lower bound. TC2 uses income data (both individual and zip code) and adds four hours spent at the dive site (in and out of the water) to calculate the travel cost.

Calculating willingness to pay (WTP) is complex with this kind of model and ours is especially involved since there are over 50 alternative choices for sites to collect abalone. The generic formula for WTP is known as the "log-sum" formula and is given by:

$$WTP = \frac{1}{\theta}\left[h \sum_{j=0}^{J} e^{V_j^1} - h \sum_{j=0}^{J} e^{V_j^0} \right]$$

Where j represents the recreation site, *j*=1, 2 ... J, and superscripts 0,1 represent the initial and final situations, respectively. θ is the coefficient on travel cost (in absolute value). The final situation is characterized by whatever policy (or, generically, change) we are evaluating, which could include a change in a site's attributes, that is, in elements of every V*j*, or elimination of one or more sites. In this latter case, the site(s) in question simply disappear from the sum of values of all the sites.[2]

On the other hand, if the quality of an attribute changes for all sites, the WTP is:

$$WTP = \frac{\beta_1 \Delta X}{\theta}$$

The coefficients βi capture preferences for various levels of the attribute. A positive and significant coefficient ($\beta i > 0$) means that the increase in the attribute results in a higher likelihood that the site is selected. The other relevant coefficient for calculating the WTP is θ, which captures the reduction in an individual's utility as the travel cost rises (or the marginal utility of income in absolute value). Regressions were run in the Stata software package (V12) using

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2 In other words, we replace $\sum_{j=0}^{J} e^{V_j^1}$ with $\sum_{j=0}^{J_k} e^{V_j^1}$ in which $J_k < J$.

a conditional logit model. An additional regression to test the validity of results was run on the travel-cost-only data with a mixed logit model, which accounts for the possible independence of irrelevant alternatives (IIA) and captures the unobserved heterogeneity of the sample.

In addition, to gain an understanding of the trajectory of recreational value over the years, we applied the per-trip value calculated for 2013 to the years 2000-2012 and 2014. Total fishing trips for these years was calculated by multiplying the number of report card holders by the average trips per report card holder as reported in the telephone surveys for each year, including respondents who took no trips. Average trips figures were available for 2003-2006, 2008, 2012 and 2014, so these are the years for which total values were calculated. This extrapolation provides only a very coarse approximation; per-trip values can be expected to vary year to year with changes in regulations, abalone abundance, weather, economic conditions and other factors. Future research should use trip values specific to each year, work that was beyond the scope of this study.

Results

The per-trip recreational value of each site was estimated by two travel cost models (Table 2). The values appear as negative numbers because they refer to the loss that would result if a particular site were closed or otherwise no longer available. The sites for which the values are greatest are largely clustered between Albion and Fort Bragg on the Mendocino coast, with losses in the range of $2.50-$5.00 per trip. The modest figures are explained by the fact that divers can simply opt for another of the long list of sites if only one is closed; sites are partially substitutable. The impact of closing all sites simultaneously is a loss $219-$406 per trip, depending on the model chosen. The 2013 telephone survey reports 30,678 fishers take on average 3.6 trips per year. The total net recreational value estimated for the fishery in 2013 was between $24M based on the driving cost alone (TC1), and $44M when considering both driving cost and the time spent on the trip (TC2) (Figure 2).

Travel cost is shown to be significant at the 99.9 percent confidence level in all three models (Table 3). The results of the two regressions runs to generate the value estimates, plus, in the rightmost column, the mixed logit regression run as an additional test of the validity of the analysis are shown revealing the concordance of the 3 models (Table 3). Of the site characteristics, impact from the 2011 HAB, bathrooms, boat launch and exposure to swell (listed in descending order of their coefficients) were all significant at this level in all models and had the expected signs (negative or positive impact on utility). Ease of access to the water was significant at the 95 percent confidence level in the TC1 and TC2 models but not in the mixed logit. The requirement to pay for parking, on the other hand, was significant (99 percent confidence level) for the mixed logit only. The HAB attribute, which is associated lower abalone abundance, has by far the largest coefficient (impact on site choice). The affected Sonoma County sites received less visitation despite their closer proximity to the major population centers around San Francisco.

Extrapolating the per-trip values for 2013 to other years, we show an initial period of steady recreational values (2003-2005) near $40M, followed by a peak in value in 2006 of just under $50M (Figure 2). The values for 2008 and 2012 were similar to the estimate for 2013 ($44M). The slightly lower values in the early 2000s were due to a lower average number of trips taken per report-card holder. The value dropped dramatically in 2014 (~$32M) as report card sales fell by 16 percent, to their lowest levels within the 15 years for which we have data. Trips per fisher also declined, by 13 percent, in the 2014 season.

Table 2. —Recreational value by site shown as the economic wellbeing reduction per trip, in dollars, that would result from closing each fished site individually. Cs = consumer surplus; wtp = willingness to pay). Sites appear in order from north to south.

		Model 1: Driving costs only		Model 2: Driving costs and time	
COUNTY	**SITE**	Mean	Standard deviation	Mean	Standard deviation
Del Norte	Crescent City	-0.33	2.83	-0.54	3.44
Del Norte	Other Del Norte County	-0.25	0.88	-0.53	1.91
Humboldt	Trinidad	-0.54	1.93	-1.22	4.73
Humboldt	Punta Gorda	-0.20	0.37	-0.43	0.70
Humboldt	Shelter Cove	-0.88	1.07	-1.75	1.74
Humboldt	Other Humboldt County	-1.07	1.41	-2.14	2.28
Mendocino	Usal	-0.94	0.49	-1.86	0.88
Mendocino	Hardy Creek	-0.79	0.31	-1.51	0.56
Mendocino	Abalone Point	-1.03	0.38	-1.99	0.70
Mendocino	Westport	-0.73	0.27	-1.39	0.50
Mendocino	Bruhel Point	-0.27	0.10	-0.52	0.18
Mendocino	MacKerricher State Park	-1.37	0.45	-2.61	0.84
Mendocino	Glass Beach	-1.47	0.48	-2.78	0.89
Mendocino	Georgia Pacific Mill	-1.68	0.54	-3.14	0.99
Mendocino	Todd's Point	-1.30	0.41	-2.41	0.74
Mendocino	Hare Creek	-1.62	0.51	-3.06	0.95
Mendocino	Mitchell Creek	-0.64	0.15	-1.21	0.27
Mendocino	Jughandle State Reserve	-1.05	0.21	-1.95	0.39
Mendocino	Caspar Cove	-1.52	0.29	-2.88	0.55
Mendocino	Russian Gulch State Park	-2.70	0.49	-5.04	0.89
Mendocino	Jack Peters Gulch	-0.75	0.13	-1.41	0.23
Mendocino	Mendocino Headlands	-2.31	0.40	-4.29	0.73
Mendocino	Gordon Lane (Spring Ranch)	-0.46	0.07	-0.88	0.14
Mendocino	Van Damme State Park	-2.61	0.41	-4.86	0.77
Mendocino	Dark Gulch	-1.05	0.16	-1.97	0.29
Mendocino	Albion Cove	-2.99	0.45	-5.54	0.82
Mendocino	Salmon Creek	-0.83	0.12	-1.53	0.22
Mendocino	Navarro River	-1.98	0.30	-3.67	0.53
Mendocino	Elk	-2.45	0.42	-4.53	0.73
Mendocino	Point Arena Lighthouse	-0.90	0.19	-1.68	0.33
Mendocino	Point Arena (Arena Cove)	-3.60	0.84	-6.58	1.44
Mendocino	Moat Creek	-3.14	0.76	-5.74	1.32
Mendocino	Schooner Gulch	-1.03	0.26	-1.89	0.46
Mendocino	Anchor Bay	-1.14	0.33	-2.18	0.62
Mendocino	Robinson Point	-0.21	0.07	-0.40	0.12
Sonoma	Gualala Point	-0.34	0.11	-0.63	0.20
Sonoma	Sea Ranch	-0.58	0.19	-1.09	0.36
Sonoma	Black Point	-0.42	0.14	-0.79	0.27
Sonoma	Stewart's Point	-0.49	0.17	-0.93	0.33
Sonoma	Rocky Point	-0.22	0.08	-0.42	0.15
Sonoma	Horseshoe Cove	-0.60	0.21	-1.13	0.42
Sonoma	Fisk Mill Cove	-1.10	0.42	-2.07	0.81
Sonoma	Salt Point State Park	-1.07	0.41	-2.00	0.81
Sonoma	Ocean Cove	-1.11	0.43	-2.09	0.86
Sonoma	Stillwater Cove	-1.53	0.61	-2.87	1.20
Sonoma	Timber Cove	-0.99	0.39	-1.86	0.79
Sonoma	Fort Ross	-0.99	0.40	-1.85	0.80
Sonoma	Reef Campground (Pedotti)	-0.79	0.32	-1.47	0.65
Sonoma	Jenner	-0.41	0.17	-0.76	0.35
Sonoma	Bodega Head	-1.57	0.68	-2.92	1.47
Marin	Tomales Point	-0.92	0.41	-1.69	0.91
Sum CS per site		-58.97	0.85	-110.64	1.04
Total WTP for closure of all visited sites		-218.71	24.12	-405.84	43.36

TABLE 3. —Regression results.

	Model 1	Model 2	Model 3
	TC1	TC2	TC1 mixed logit
TC1	-0.0173***		-0.0221***
	(-18.73)		(-19.93)
TC2		-0.00919***	
		(-18.56)	
Access	0.114*	0.105*	-0.0815
	(2.41)	(2.23)	(-0.99)
Boat launch	0.574***	0.575***	0.692***
	(7.94)	(7.95)	(4.18)
Parking	0.0764	0.0847	0.0679
	(1.40)	(1.55)	(0.87)
Bathrooms	0.627***	0.626***	0.817***
	(7.40)	(7.38)	(6.47)
Exposure to ocean swell	-0.377***	-0.373***	-0.374***
	(-8.03)	(-7.99)	(-4.54)
Harmful algal bloom	-1.470***	-1.421***	-2.932***
	(-15.90)	(-15.58)	(-10.30)
Pay for parking	0.0758	0.0755	-0.516**
	(1.08)	(1.08)	(-2.85)
Number of tripstrips	15201520	15131513	15131513

t statistics in parentheses $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

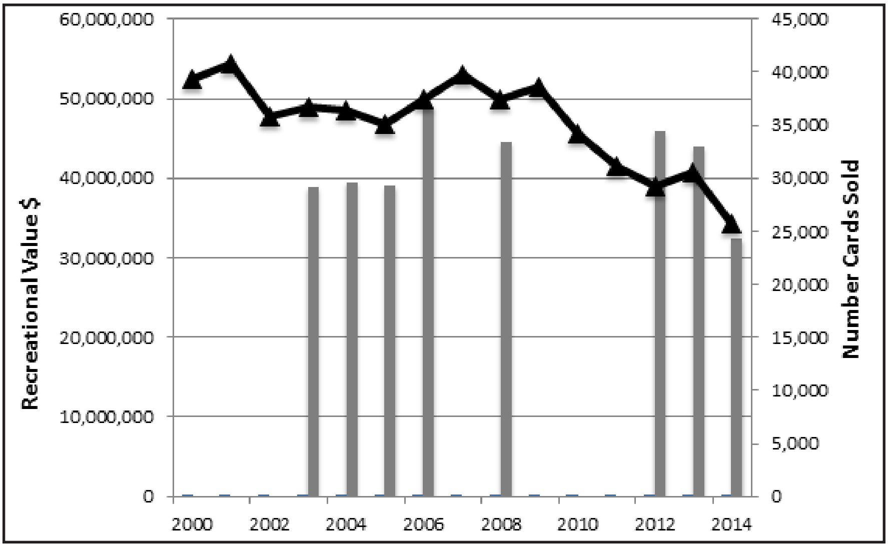

FIGURE 2.—Recreational value of the red abalone fishery in northern California for the years with data on the number of trips extrapolating the per-trip value from 2013 to the other years (2003, 2004, 2005, 2006, 2008, 2012, 2014) shown using the height of the bars. The second Y axis shows the total number of abalone report cards sold per year from 2000-2014 shown using the solid triangles. Note: the automated license system went into effect in 2010 reducing the possibility of illegally purchasing two cards in one year.

The 2014 fishing season was the first year marked by the full impact of the HAB event and associated regulation changes, such as the reduction in the annual bag limit, the new late start time (8:00AM) and the closure of the historically most heavily used site in the fishery – Fort Ross State Park.

Finally, we report descriptive statistics of the fishers from a sample to give a sense of respondent characteristics. We find that 95 percent of the sample was from California and 92 percent were male. The age distribution shows 73 percent over the age of 35, with an average of 15 years of abalone fishing experience (Figure 3). As noted above, the average number of trips was 3.6 and the average days fishing was just over 4.0, with an average of 8.4 abalone caught during the season. Note that these figures include respondents who purchased report cards but did not end up fishing.

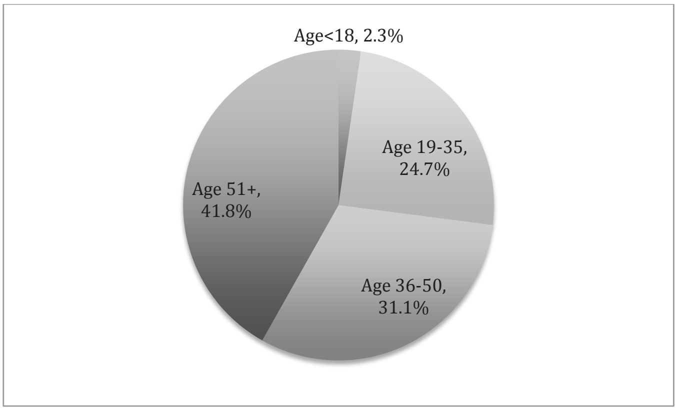

FIGURE 3.—Age distribution of 2013 abalone fishers included in sample.

DISCUSSION

The red abalone fishery is worth \$24-\$44 M in annual non-market benefits to recreational fishers (Figure 2). We consider these conservative estimates of the value of the fishery because they are based on travel and time costs alone, excluding other trip related costs (lodging and meals), as well as associated gear (e.g. wetsuits, abalone floats, irons and licenses). These results are based on the 392 respondents many of whom (>40%) are more than 50 years old. Chen et al. (2013) found, that abalone fishers spent an average of \$193 on dive equipment, \$167 on lodging and camping and \$140 on food and beverages from stores, which adds up to 50 percent of overall expenditures. Transportation expenses (excluding the opportunity cost of time, accounted for 28 percent of spending). While their study was based on only 90 respondents, the results do suggest that collecting additional data for a fuller accounting of travel costs is warranted in future years to get a fuller picture of the economics of this fishery.

We recommend some modest changes in the routine annual data collection effort that would permit creating a more robust time-series of economic value for the fishery. The travel-cost estimation method as applied here requires data on trips taken by individual fishers, including the destination, associated spending and number of people traveling together for each trip, as well as demographic information on the fishers. We recommend that this sort of data on fisher trips (rather than fishing day) be collected directly through the annual telephone survey of report card holders. To date, surveys have not collected data on individual trips. As a result, in this analysis, we reconstructed a profile of each trip based on location and date information reported on the capture of individual abalone, cross-referenced with the number of trips each respondent reported. Collecting specific trip data would save substantial time on analysis and permit inclusion of costs beyond driving expenses and the opportunity cost of time, allowing for a more comprehensive estimate of fishery value. This would avoid the strategy employed in this analysis, using per-trip values from 2013 and extrapolating these to other years. Finally, the recommendation we are making to collect trip data would facilitate an economic impact analysis.

The multi-site travel-cost estimation method is useful when weighing the economic effects of management actions which would open or close one specific fishing site or a group of sites. Multi-site information can be used to estimate the specific economic losses (or gains) from closing (or opening) sites, based on their attributes and levels of use. In this case the site information was useful in understanding the economic impacts of the regulation changes made following the HAB. The full impacts of the HAB and the associated regulation changes, including a reduction in the annual bag limit, the later start time, and the closure of Fort Ross took effect in the 2014 season. In 2014, the total value of the fishery dropped by $12M from $44M to $32M coincident with a 16 percent decline in report card sales and a 13 percent drop in average annual fishing days per fisher. Although we cannot assign causality, the figures do give managers a quantitative indication as to the economic dimensions of the HAB event and subsequent regulation changes.

Because similar valuations are lacking for other major marine recreational fisheries in California, we have little basis for comparisons. Most economic analyses of California fisheries have consisted of estimates of recreational expenditures or gross commercial revenue to fishers. These estimates are not comparable to the figures we have generated with the TCM, which is the net benefit–the consumer surplus–accruing to fishers of the fishery. Expenditures for the recreational spiny lobster (*Panulirus interruptus*) fishery in southern California, was calculated at $37M per year (Hackett et al. 2013). While, the two largest commercial fisheries in California (by ex-vessel value) are market squid (*Doryteuthis [Loligo] opalescens*) ($58M) and Dungeness crab (*Metacarcinus [Cancer] magister*) ($46M) from 2008-2012 (Rogers-Bennett and Juhasz 2014). Without venturing any speculations about the economic value of these fisheries–which is equal to the producers' profits plus consumer surplus–we simply note that their gross expenditures are of a similar magnitude as the economic value of the red abalone fishery. While these are apples-and-oranges comparisons, we can look at additional calculations to estimate comparable economic impact figures for red abalone. The total economic impact of red abalone recreational fishing from previous work was found to be $26.7M for the 2014 season (Reid et al. 2016). Direct expenditures, the figure most similar to the $37M estimated by Hackett et al. (2013) for spiny lobster, were found to be $18.6M for red abalone in California (Reid et al. 2016) (Figure 4).

Conclusions

The loss of both the recreational and commercial abalone fisheries in southern California in 1997 makes it clear that this resource is vulnerable to depletion and collapse. The economic value estimates presented here demonstrate that there are tens of millions of dollars in recreational benefits at stake if the North Coast recreational fishery were to suffer the same fate. The economic importance of the fishery provides policy-

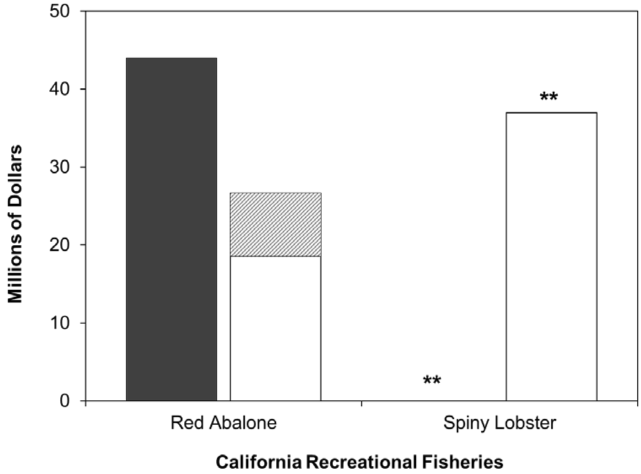

FIGURE 4.—Economic Value And Economic Impact Of Northern California Red Abalone Recreational Fishery Compared to spiny lobster economic impact. Black bar = Economic value from travel-cost method (this study); white bar = economic impact: direct expenditures (red abalone – (Reid et al. 2016); spiny lobster - (Hackett et al. 2013)); patterned bar = economic impact: indirect + induced costs (Reid et al. 2016). "**" = no comparable analyses available for spiny lobster other than for direct expenditures.

makers and managers an indication of the high priority of investing in science and law enforcement to sustain the resource. Analyses such as this one have yet to be done for many recreational California fisheries and are desperately needed to inform management. Quantifying the economic importance of a fishery reveals that an investment in resource management can enhance the long term economic benefits derived from the fishery.

Acknowledgments

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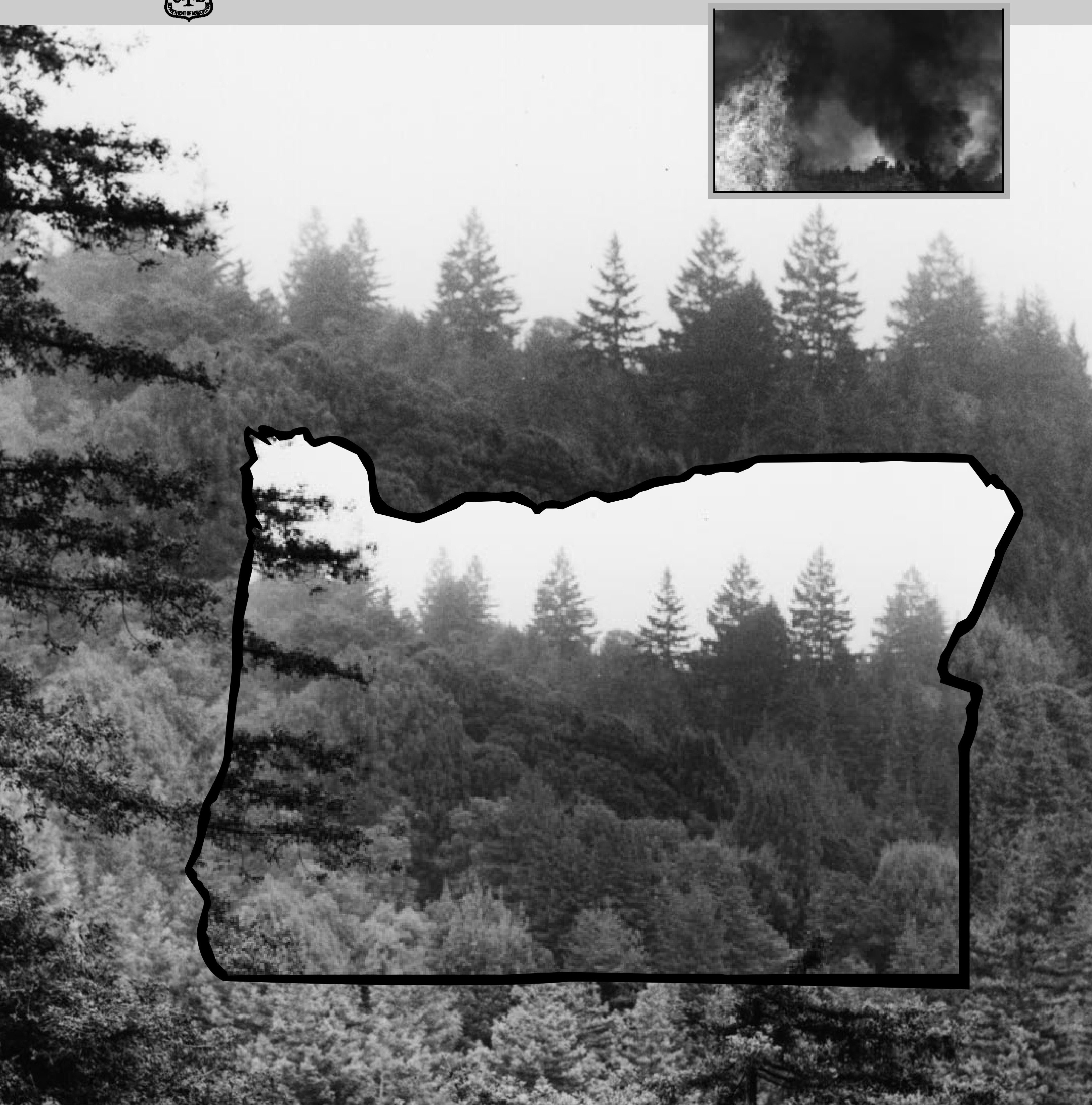
Forest Service

**Pacific Southwest
Research Station**

Research Paper
PSW-RP-229-Web

A Contingent Valuation Study of the Value of Reducing Fire Hazards to Old-Growth Forests in the Pacific Northwest

John B. Loomis   Armando González-Cabán   Robin Gregory



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A contingent valuation methodology was applied to old-growth forests and critical habitat units for the Northern Spotted Owl in Oregon to estimate the economic value to the public in knowing that rare and unique ecosystems will be protected from fire for current and future generations. Generalizing to the whole state, the total annual willingness-to-pay of Oregon residents ranges from $49.6 to $99 million. In terms of old-growth forests protected from fire, the value is $28 per acre.

Retrieval terms: contingent valuation, fire economics, NOAA, nonmarket resources, old-growth valuation, willingness-to-pay

The Authors:

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A Contingent Valuation Study of the Value of Reducing Fire Hazards to Old-Growth Forests in the Pacific Northwest

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USDA Forest Service
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Contents

In Brief

There is a growing recognition that protection of forest products beyond recreation needs to be incorporated into decisionmaking. Valuation of these other products often reflects people's desire to know that rare and unique ecosystems exist (existence value) and will be protected for future generations (bequest values) and that they will be available for visits at future times (option values). Existence and bequest values have been quantified (in dollar terms) to stop logging of old-growth forests in Washington and Colorado but not to protect these ecosystems from fire.

About 7 million acres of the remaining old-growth forests in the Pacific Northwest have been designated as Critical Habitat Units (CHU's) for the Northern Spotted Owl by the USDI Fish and Wildlife Service. This designation eliminates clearcutting and severely restricts the logging that can be done. The last significant threat to preservation of these habitats stems from possible catastrophic fires. Fire management policies can reduce the frequency of human-caused fires and the extent and severity of all fires.

The main objective of this research is to provide a case study of the contingent valuation method (CVM) for measuring the economic value (sum of recreation use, option, existence, and bequest values), and thus willingness-to-pay (WTP), for protecting old-growth forests in Oregon from catastrophic fires. The CVM obtains an individual's estimate of WTP for use or preservation of natural resources through creation of a simulated market. The simulated market is conveyed in a mail questionnaire or a telephone or in-person interview. In this research, we used a mail questionnaire.

All technical information on fire and fire effects was obtained from USDA Forest Service and USDI Fish and Wildlife personnel in Oregon and was used in the development and pretesting of the survey questionnaire. The following are three important elements of all CVM surveys: resource to be valued, financial mechanism to be used to pay, and the question format used to elicit the respondent's dollar amount of WTP.

Two versions of the survey were sent to two random samplings of 500 Oregon households each. In Version 2, respondents were reminded, before they answered the willingness-to-pay question, about other substitute resources and their budget constraint; in Version 1, respondents were not reminded. Households were randomly assigned to one of 20 alternative program cost levels of the two treatment samples. The overall survey design and mailing procedure followed Dillman's total design method. The results and response rates between versions were almost identical. The mean open-ended WTP responses were $33 for Version 1 and $36 for Version 2. The mean dichotomous choice WTP responses were $92 for Version 1 and $98 for Version 2. Pooling the data showed a mean dichotomous choice WTP of $90 per household.

The similarity of WTP responses across survey versions can be interpreted to mean that respondents already take into account their budget and competing public and private alternative expenditures when providing their WTP responses. An alternative interpretation is that when dealing with any hypothetical scenario, people do not seriously consider the real dollar consequences of their survey responses regardless of whether they are reminded. Without a validity test forcing respondents to actually pay, we cannot distinguish between these two possible explanations.

The external validity of the sample values is of critical concern when applying the findings to the population (Arrow and others 1993). Applying the findings to Oregon's population yields WTP values ranging from $45 to $90 per household or a state aggregate of $49.5 million to $99 million

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Retrieval terms: contingent valuation, fire economics, NOAA, nonmarket resources, old-growth valuation, willingness-to-pay

annually, depending on how similar the values of nonrespondents are to those of respondents.

Dividing a middle estimate of WTP of $84.6 million annually by the 3,500 acres that would no longer burn results in a value to the public of $24,170 per acre saved from fire. In terms consistent with the USDA Forest Service fire management analysis system, dividing the $84.6 million by the total acreage of old-growth forests in CHU's for the Northern Spotted Owl yields a value to the public of $28 per acre protected.

Current Federal fire management policies take into account the economic values of several traditional forest products such as timber, range, water, game wildlife, and recreation in decisions about the type and level of fire suppression. Many other important forest "products" including preservation of biodiversity and related nongame animals, however, are not formally included as part of the USDA National Fire Management Analysis System (NFMAS).

There is a growing recognition within the Wildland-Urban Interface Research Work Unit at the Pacific Southwest Research Station's Forest Fire Laboratory in Riverside, California, that protection of forest products beyond recreation needs to be incorporated into decisionmaking (González-Cabán and Chase 1991, González-Cabán 1993). Valuation of these other products often reflects peoples' desire to know that rare and unique ecosystems exist (e.g., existence value, first proposed by Krutilla [1967]) and will be protected for future generations (bequest value) and that they will be available for visits at future times (option value). The existence and bequest values have been quantified (in dollar terms) to stop logging of old-growth forests in Washington (Rubin and others 1991) and Colorado (Walsh and others 1984), but not for protecting these ecosystem types from fire.

In the Pacific Northwest only a small percentage of old-growth ecosystem remains on National Forest lands. About 7 million acres of these old-growth forests have been designated as critical habitat units (CHU's) for Northern Spotted Owl by the USDI Fish and Wildlife Service. This designation eliminates clearcutting and severely restricts logging. However, one significant threat to preservation of habitat in these areas stems from possible catastrophic fires. Fire management policies can reduce the frequency of human-caused fires and the extent and severity of all fires.

Introduction

The protection of old-growth forests was identified as a major concern at workshops on defining what fire managers thought were the major fire management issues in the Pacific Northwest (Gregory and von Winterfeldt 1992). These workshops were held in Regions 5 (California) and 6 (Oregon and Washington) of the Forest Service. The workshops' primary purpose was to develop an understanding of the nature and structure of the nonmarket forest resource values that could be affected by alternative fire management strategies. Participants specifically identified lack of economic values of protection of old-growth forest that could be formally represented in fire management models. This paper provides a case study of the contingent valuation method (CVM) for measuring the total economic value (the sum of recreation use, option, existence, and bequest values) (Randall and Stoll 1983) of protecting old-growth forests in Oregon from catastrophic fires.

Literature Review

Vaux, Gardner, and Mills (1984), in one of the first studies of the perception of fire-influenced landscapes and its effect on the land's recreation quality, stated, "Both economic and psychological methods could be used to evaluate the effects of fire on forest recreation. These methods rely on direct and inferential means to assess the values of outdoor recreation. The most suitable of these approaches appears to be contingent market valuation—a direct economic technique that uses personal interviews. A hypothetical market transaction environment is set up within which values are estimated." This approach has been used to assess the impact of insect infestations and timber cutting on forest environments. The effects of such infestations and cuttings are similar to the effects of fire. Vaux, Gardner, and Mills go on to state that "willingness-to-pay (WTP) is an appropriate measure for valuing the effects of fire on forest recreation" (Vaux and others 1984:1). Willingness-to-pay represents the maximum amount a person would be willing to pay for the resource in question under the proposed scenario (Mitchell and Carson 1989). The study by Vaux and others (1984) involved about 70 students rating photographs of burned and unburned forests and then expressing a willingness-to-pay for the preferred scene. The primary objective of their research was to demonstrate the viability of such an approach.

Our proposed research takes the study by Vaux and others (1984) forward in several directions. First, our sample is much larger in size than theirs and represents the general population rather than college students. Second, we are interested not only in how fire affects recreational benefits of the forest over time but also in the magnitude of what are sometimes called non-use or preservation values associated with maintaining the forest in its current condition (Walsh and others 1984). These preservation values include the option for future recreation use, the benefit from just knowing the forests are maintained as habitats for wildlife, and the knowledge that future generations will have these forests in much the same form as we do today. In this study, we emphasize these values as well as the benefits of ecosystem and critical habitat that old-growth forests provide for nongame wildlife such as spotted owls, salmon, and steelhead, as well as scenic beauty and water quality. Third, we explicitly include the concept of opportunity costs in that we ask participants to state their willingness-to-pay, in dollars of personal income, to receive the specified benefits.

In this sense, our study is an extension of the studies by Rubin and others (1991), Hagen and others (1992), and Lockwood and others (1993) in which individuals were asked their maximum WTP to protect old-growth forests from logging and to ensure their continued existence as habitat for spotted owls. In many cases, fire is the next major threat to the protection of these forests. Our study and survey design will draw from elements in each one of these CVM studies. In addition, we draw upon the workshops of Gregory and von Winterfeldt (1992), who investigated the nonmarket forest resource values that are affected by alternative fire management strategies.

Contingent valuation is a widely used method for obtaining WTP for recreation, option, existence, and bequest values (Mitchell and Carson 1989). It is recommended for use by Federal agencies for performing benefit cost analysis (U.S. Water Resources Council 1983), for valuing natural resource damages (U.S. Department of Interior 1986). Its use was upheld by the Federal courts (U.S. District Court of Appeals 1989).

The CVM obtains an individual's estimate of their WTP for use or preservation of natural resources through creation of a simulated market. The simulated market is conveyed in a mail questionnaire or a telephone or in-person interview.

Development of the Survey

Development of Technical Information on Fire

Before the survey design, the research team met with USDA Forest Service fire management specialists and wildlife biologists to ensure a good understanding of the natural resources at risk from fire in old-growth forests and spotted owl critical habitat areas. These specialists were from the Willamette National Forest in Eugene, Oregon and the USDA Forest Service Regional Office in Portland, Oregon. We went through a checklist of multiple uses and species and asked whether the forest resources would be either adversely affected by fire in the short term, positively affected by fire in the short term, or not affected by fire. The results of this discussion were used to describe to respondents the likely effects of fire.

In addition, this meeting provided initial information on the frequency and extent of actual fires under current management. As a result of this meeting, we secured map overlays from the Forest Service on fire frequency and from the USDI Fish and Wildlife Service on CHU's. From these overlays, we developed our statistics on frequency and extent of fire in spotted owl CHU's.

The other main accomplishment of this meeting was the initial development of a list of additional fire management actions that could be undertaken by the Forest Service and Bureau of Land Management (BLM) to reduce the frequency and extent of fire in the CHU's. We titled this the Fire Prevention and Control Program. After discussion with fire management officials, three main categories of this program were identified. These are: "greater fire prevention efforts," "earlier fire detection," and "quicker and larger fire control response." In the survey, the respondent is given one-sentence elaborations of each of these three management actions *(appendix A).*

Focus Groups and Pretesting

Once the fire statistics and maps of CHU's for Oregon were developed, we held two small focus groups at Decision Research (a scientific research firm) in Eugene with Oregon residents. One of the primary objectives was to determine whether our basic Fire Prevention and Control Program was understandable and realistic. We also sought to explore alternative ways to describe the extent or amount of area burned each year. Another objective was to discuss acceptable ways of funding this program. For example, we asked whether it was believable that only Oregon residents would pay for the program or whether all residents of the United States must pay. In addition, the focus groups provided us with a better understanding of the language that participants normally used to describe events related to forest fire.

After meeting with these focus groups, a complete survey was drafted by members of the study team. The revised instrument was pretested on a small sample of Oregon residents who filled out the survey at Decision Research in Eugene, by Forest Service employees at the Forest Fire Laboratory in Riverside, California, and by several staff members at the University of California, Davis. Each individual participating in the pretest was asked to answer a follow-up checklist to investigate several items that have been problems for past CVM surveys. For example, we checked to see whether individuals understood that the fire control program protected just spotted owl areas in Oregon and whether they realized that all residents of the United States would pay. Several modifications were made to the survey instrument on the basis of these results (e.g., bolding or underlining was added for emphasis or survey layout was changed). Finally the pretest was used to establish an appropriate range of bid amounts for the dichotomous choice question.

Structure of the Survey

Nonmonetary Measures of Relative Importance

Before directly asking how much respondents would pay for a fire protection program for old-growth forests, it is important to allow the respondents an opportunity to reflect on why they might care about these forests. Cummings and others (1986) call this "researching their preferences" or, in other words, collecting your thoughts on this topic. Certainly residents of Oregon have been exposed to large and repeated media coverage about old-growth forests and spotted owls. In the weeks before the first mailing of our survey, the President, Vice-President, and nearly half of the President's cabinet came to Portland, Oregon, for an "Owl Summit." This event was highlighted, in one way or another, in every local newspaper and received extensive television network coverage. Thus, we believe Oregon residents have some knowledge about the natural resources present in old-growth forests and have had much opportunity to reflect on what these resources mean to them.

The first set of questions asked about the relative importance of old-growth forests for recreation use, providing timber, as habitat for plants and wildlife, providing jobs, and providing scenic beauty in Oregon. A 5-point Likert scale allowed individuals to rate the relative importance of these various reasons for valuing old-growth forests in Oregon. This neutral response format (that precedes the dollar valuation questions) also aided in understanding the WTP amounts people provide later in the survey.

Steps in Developing a Contingent Valuation Method Survey

Any CVM survey design involves three elements: (a) portrayal of the resource to be valued; (b) description of the particular financial mechanism to be used to pay for the resource; e.g., property taxes, utility bills, trust funds, etc.; and (c) the question format used to elicit the respondent's dollar amount of WTP.

In this case, the resource to be valued was a fire prevention and control program for 3 million acres of old-growth forests in CHU's of Northern Spotted Owl in Oregon. This point was emphasized by the half-page map of western Oregon showing the CHU's on the third page of the survey (directly across from the WTP question). Discussion with USDA Forest Service fire management specialists suggested that increasing three fire program elements would reduce the number and extent of fires. After several focus groups and pretests (discussed above), these three elements were refined into the Fire Prevention and Control Program that were listed and briefly described to respondents in the survey: (a) Greater Fire Prevention; (b) Earlier Fire Detection; and (c) Quicker and Larger Fire Response. The respondents were told that greater effort and funding in all three of these areas would cut in half the current annual number of fires (300) and acreage (7,000) burned in the CHU's. The statistics on the current number of fires and acreage burned were developed from map overlays supplied by the USDA Forest Service and USDI Fish and Wildlife Service. To make the reduction more meaningful, we described the acreage relative to the number of city blocks and square miles involved.

The means by which all households would pay was framed as a voter referendum. Individuals were told *Because Oregon's old-growth forests are also Federally designated CHU's for the threatened Northern Spotted Owl, all households in the United States would pay into a Special Oregon Old-Growth Fire Control Program. By law this fund could be used only for fire protection in Federally owned old-growth forests shown on the map. Adoption of the program would be decided as part of a national election. Following this statement was the actual WTP question: Suppose the Oregon Old-Growth Fire Prevention and Control Program proposal were on the next ballot. This program would reduce by half the number of acres of old-growth forests in CHU's that would burn in Oregon each year. If it cost your household $___ each year, would you vote for this program? This was followed by the open-ended WTP question What is the maximum your household would pay each year for the Fire Prevention and Control Program to reduce in half the number of acres of old-growth forests in CHU's that burn each year in Oregon?* (See *appendix A* for the complete survey).

Questions to check comprehension following the pretest indicated that a majority of individuals understood that this program pertained only to Oregon's old-growth forests and that **all** U.S. households would pay.

Given the voter referendum question, the WTP question format was of the dichotomous (yes/no) type. The dichotomous choice format mimics an actual vote by simply asking whether the person would vote (e.g., pay) for the item if it would cost the household a particular dollar amount each year. In this case the individual must just decide whether the value to him or her is worth at least this price. Since the printed dollar amount varies across the sample, the dichotomous choice format allows the analyst to statistically trace out a demand relationship between the probability of a "yes" response and the dollar amount. The basic relationship is:

$$\text{Prob(Yes)} = 1 - \left\{1 + \exp\left[B_0 - B_1\overline{X}_1 + B_2\overline{X}_2 + B_3\overline{X}_3 + \ldots B_n\overline{X}_n\right]\right\}^{-1} \qquad (1)$$

where **B**'s are coefficients to be estimated using logit statistical techniques and **X** is the dollar amount the household is asked to pay.

From equation 1, Hanemann (1989) provides a formula to calculate the expected value of WTP as:

$$\text{Mean WTP} = \left(1/B_0\right) \times \ln\left(1 + \exp\left[B_0 - B_1\overline{X}_1 + B_2\overline{X}_2 + B_3\overline{X}_3 + \ldots B_n\overline{X}_n\right]\right) \qquad (2)$$

This formula applies if reducing fire is seen as beneficial by all respondents. However, if this is not the case, then the unrestricted WTP (B_0/B_1) is appropriate, which is also equal to the median in a linear model.

Twenty different bid amounts ranging from $2 to $300 were randomly assigned to survey respondents. The range was picked such that at the low end, anyone who valued old-growth forests or the Northern Spotted Owl would very likely indicate they would pay $2, while almost no one was expected to pay $300 each year.

Following the WTP question were two questions designed to investigate the reasons behind a person's answers to the WTP questions. One question probed responses for persons indicating they would not pay anything at all for the fire prevention and control program (respondents indicated whether they would pay or not when responding to the WTP questions). It is customary to determine whether such response represents a valid value or a protest to some feature of the simulated market. Six response categories were provided including: (a) this program is not worth anything to me; (b) I cannot afford to pay at this time; (c) I do not think the program would work; (d) It is unfair to expect me to pay; (e) I am opposed to any new government programs; (f) other. Categories (a) and (b) represent valid reasons for not being willing to pay. These responses are retained for calculating WTP. However, responses (c)-(e) represent rejection of the basic premise of the simulated market and are not retained for purposes of calculating WTP. These rejections may not reflect signals about the value of the commodity, but rather may reflect the respondent's concerns about the effectiveness of the program, equity of the financing, other features of the survey, or simply the political ideology of the respondent.

The second WTP check question was asked of those individuals who indicated they would pay the posited amount. The five categories were (a) This program is worth at least this much to me; (b) I feel we have a duty to protect old-growth forests; (c) to contribute to a good cause; (d) to pay my fair share to protect old-growth forests; (e) other. Clearly, category (a) is a valid response as this is what we are trying to measure. There has been some debate about whether those checking off (b), (c), or (d) are really valuing the resource or program, simply donating out of a sense of duty, or for a "warm glow" that donating to a good cause provides (Kahnemann and Knetsch 1992).

Finally, simple demographic questions such as age, education, membership in environmental organizations, and income were asked. The final survey instrument was typeset and made into a booklet containing text and graphics.

Two Survey Versions for Hypothesis Testing

As part of the survey development process, we identified a critical CVM design issue that could be tested: whether making explicit to the respondent that there were many substitute public programs that needed funding and that their limited household budget would limit the respondent's WTP. Both of these points were recommendations of the National Oceanic and Atmospheric Administration's (NOAA) Blue Ribbon Panel on Contingent Valuation (Arrow and others 1993). To allow for testing of whether reminding respondents that they may have to pay for other environmental programs and that they had a limited budget, we added the following text immediately before the WTP question in one-half the surveys mailed: *Before you vote, we would like you to keep in mind that this fire control program would affect only old-growth forests and spotted owls in Oregon, not other states. Also remember that about 1,000 other endangered species in the United States need protection for their critical habitat. Additional money will be needed for these species and other costly environmental programs such as cleanup of abandoned hazardous waste sites and reducing air pollution. Money* *you spend on the fire program would reduce the amount of money your household will have available to spend on the other environmental problems mentioned as well as on the everyday products you buy.*

If the NOAA panel is correct, WTP—with this statement included—will be lower than WTP elicited without the statement on substitute uses of their money. The difference in WTP for the open-ended question can be evaluated with a student's t-test using the sample means and their respective standard errors. In the case of dichotomous choice CVM, the differences in responses can be compared by a statistical likelihood ratio test that will be explained in more detail later.

Sample Design

The two versions of the questionnaire were sent to a random sample of 1,000 Oregon households during spring 1993. The sample was provided by Survey Sampling Inc. Survey Sampling Inc. assigned households randomly to the two treatment samples; no other selection criteria were imposed on the sampling. The overall survey design and mailing procedure follow Dillman's (1978) Total Design Method (first mailing/postcard/second mailing). Each individual was sent a personalized cover letter on Decision Research letterhead with a personal signature. The first mailing was sent out the first week in May, with a reminder postcard 4 business days later. A second mailing of the survey, with a new cover letter, was sent to nonrespondents the first week in June.

Results

Response Rate

Table 1 provides a tally of the response rate by version and the overall response rate. The response rates were nearly identical between versions, 50 percent for version 1 and 49 percent for version 2 *(table 1)*. This response rate is typical for a general population survey using a first mailing/postcard/second mailing without any financial incentives. In addition, Oregon residents may have become overwhelmed by all the attention to the Northern Spotted Owl controversy, and some persons may have just refused to devote further attention to the issue. Below, we provide two adjustments to account for the nonresponse when generalizing the sample results to the population.

Table 1—***Response rate of survey mailing***

Variable	Version 1	Version 2[1]
Total surveys mailed	500	500
Received	220	205
Undeliverable	59	66
Deceased	2	13
Refused	9	7
Response rate (pct)[2]	50.11	48.69

[1]Following the recommendation of the NOOA Panel (Arrow and others, 1991) this version of the questionnaire included reminder that they may have to pay for other environmental programs and that they have a limited budget.

[2]Response rate = Questionnaires received/(Total surveys mailed – Undeliverable – Deceased)

Respondents to the two versions of the survey questionnaire are similar in terms of education; but, as is typical in mail surveys, the educational level of the respondents in each sample is greater than the average educational level of residents of the State of Oregon *(table 2)*. The two samples are relatively close in terms of age; but again, as is typical in mail surveys, the age of the sample exceeds the average age of the population. The income of version-1 respondents is within 1.5 standard errors of the income of version-2 respondents, so they are not statistically different. Because Survey Sampling Inc. draws the majority of names from telephone books, which are traditionally listed under the male's name, the sample overrepresents males.

As discussed below, only education was statistically significant in explaining WTP responses in the dichotomous choice question format. We also use the average level of education in the State of Oregon rather than the sample average as one way of adjusting our estimated WTP values from the dichotomous choice CVM to better reflect state demographics.

Why People Answered the Willingness-to-Pay Questions as They Did

Why They Would Not Pay: Protest Responses

Table 3 presents the reasons why some people in the two samples said they would not pay anything for the fire prevention and response program. The first two categories are not considered protest responses but, in fact, reflect legitimate reasons for stating "no, they would not pay anything." We found it encouraging to see that people indicated they could not afford to pay. This meant they took the commitment in the survey seriously.

The third through fifth categories represent what are usually classified as protest responses. These responses are usually not considered valid

Table 2—*Comparison of Version 1 and Version 2 demographic characteristics with Oregon's households*

Demographic Characteristics	Version 1	Version 2	Oregon[1]
Age (yr)	53.45	51.78	49.00
Education (yr)	14.36	14.20	13.00
Annual income ($)	35,800	39,863	32,336
Percent male	74.00	65.00	49.00

[1]Source: 1990 U.S. Census

Table 3—*Reasons why the subset of people would not pay*

Reason	Version 1	Version 2
	————*percent*————	
This program is not worth anything to me	2.3	4.4
I cannot afford to pay at this time	6.8	8.3
Subtotal	9.1	12.7
I do not think program would work[1]	8.2	6.8
It is unfair to expect me to pay[1]	4.6	6.3
I am opposed to new government programs[1]	17.4	11.7
Fire is natural and benefits forest	6.8	5.3
Other	3.2	3.9
Subtotal	40.2	34.0
Total[2]	49.3	46.7

[1]Usually classified as protest responses.

[2]Total does not add to 100 percent because not all respondents answered their respective questions.

representations of the individual's willingness-to-pay, though they do represent valid concerns. These concerns may include a rejection of the basic premise of the CVM market, some feature of the scenario, other concerns about the survey, or generalized concerns about the overall issue. These WTP responses are normally not included when WTP is computed. Thus, implicitly, the sample average WTP is applied to these individuals when the sample is expanded to the population.

Overall, 40 percent of version-1 and 34 percent of version-2 responses were considered protests. This is an unusually high protest rate; therefore, the sample average WTP is conditioned on valid survey responses, as described above, of the remaining 60 and 66 percent. In part, some of this may be due to not convincing the respondent that the fire prevention and response program would work. Respondents can perhaps be convinced in future surveys by a better explanation of how such a program would work and examples of how similar programs had worked in other areas. Alternatively, these expressions may represent opinions about government programs in general or a feeling that too much attention has been focused on the spotted owl in Oregon. To resolve the motivations behind these responses would take an in-person interview and is an important priority for future research.

Table 4 presents reasons why individuals reporting positive WTP would pay such amounts. The first category most closely matches an economic interpretation, and 17 percent (46/266) of the people providing positive WTP gave this reason. The next motivations, including having a duty to protect and paying one's fair share, reflect the majority of the respondents. Only 7 percent indicated they would pay simply to give money to a good cause. Further research is needed to better analyze and evaluate how these motivations relate to both economic and psychological indicators of value. Future work should include refinement of these categories and perhaps linking with satisfaction gained from knowing that old-growth forests and habitat are protected (Stevens and others 1991). In keeping with the economic paradigm that what matters is willingness-to-pay regardless of motivation, all positive WTP amounts and nonprotest zeros are retained in the analysis that follows.

Statistical Analysis

A second data set for statistical analysis was created from the main data set by removing protest responses. This section provides estimates of WTP based on both the open-ended WTP and the dichotomous choice questions. The empirical advantage of the dichotomous choice relates to the ease of responding to this question format. Ease of responding is evidenced by the

Table 4—***Reasons why the subset of people would pay***

Reason	Version 1	Version 2
	———*percent*———	
This program is worth at least this much	10.0	11.7
I feel we have a duty to protect these old-growth forests	13.7	21.8
To contribute to a good cause	6.4	2.4
To pay my fair share to protect the old-growth forests	14.2	8.7
Other	0.9	3.4
Total[1]	45.2	48.0

[1]Total does not sum to 100 percent because not everyone answered his/her respective questions.

fact that about 10 to 15 percent more respondents answered the dichotomous question than the open-ended questions. Nonetheless, the open-ended format provides more information per respondent and allows for a simpler comparison of WTP across versions.

Table 5 summarizes the responses to the open-ended WTP question for both versions. Two conclusions can be reached from the results in the table. First, WTP in both versions is statistically different from zero. Second, as will be discussed more below, the responses are not statistically different between survey versions.

Figure 1 further illustrates the similarity of WTP responses between the two versions of the survey and reinforces the conclusion of the point estimates that the WTP distributions are similar. The highest dollar amount in the open-ended WTP responses were given by active forest users who thought fire had a very negative effect. However, each version had one bid amount ($200 in version 1 and $250 in version 2) that appeared to be outliers because reported income of these households was just $5,000, and one did not visit forests.

Table 5—*Comparison of open-ended "willingness-to-pay" (WTP) by version*

Version	Mean	Standard error	95 percent confidence interval
	————————————*dollars*————————————		
1	35.88	3.39	29.23 – 42.52
2	32.96	4.17	24.79 – 41.13

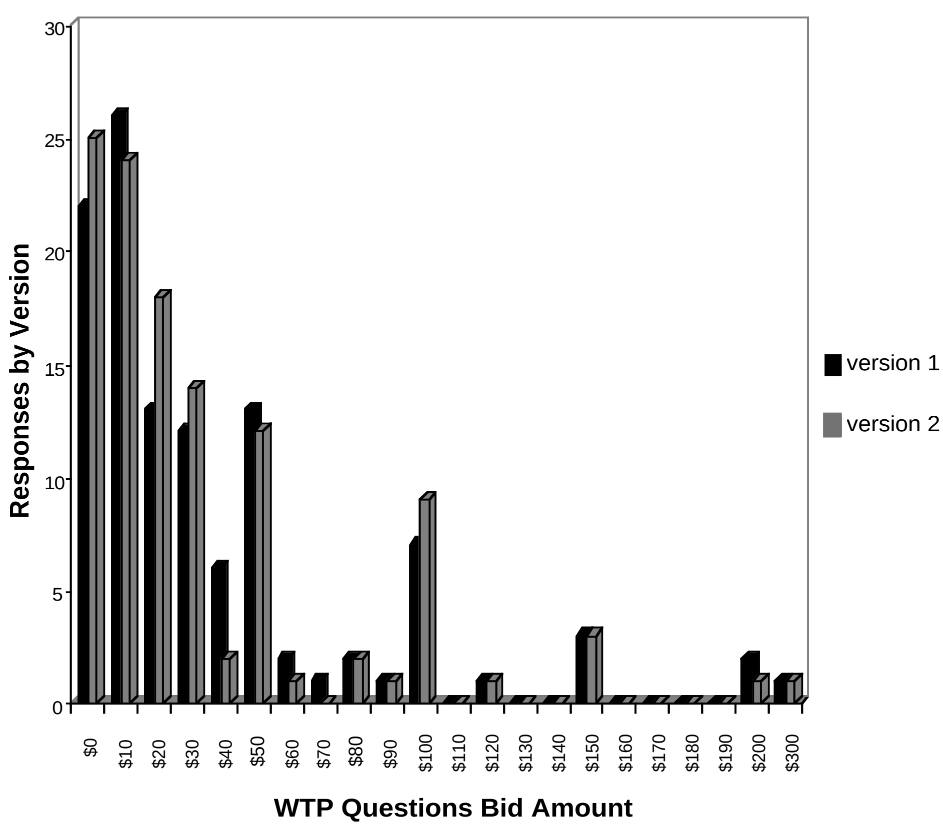

Figure 1—Comparison of response to the open-ended willingness-to-pay (WTP) question for the fire prevention and control program for old-growth forests in CHU's of Northern Spotted Owl in Oregon shows no difference between survey responses. The graph reinforces the conclusions of the point estimates that the distributions of WTP dollar amounts are similar.

Logit

Statistical Coefficients and Willingness-To-Pay

Mean WTP with the dichotomous choice WTP format is calculated from the coefficients relating the yes and no response to the bid amount using equation 2. The coefficients are typically estimated using a logistic regression (Hanemann 1984). The logit equations for the two versions are shown in *table 6*. *Appendix B* shows the distribution of yes/no responses by bid amount.

The coefficients are all statistically significant at the 0.01 level as are the overall goodness-of-fit statistics (the chi-square). The pseudo R squared, which is also calculated by comparing the restricted and unrestricted log likelihood, indicates that 13 percent (version 2) and 18 percent (version 1) of the variation in responses is explained by bid amount alone.

Using equation 2, WTP is calculated for the two versions. Once again the WTP values are quite close. As has been found in other studies (Kealy and Turner 1993), WTP from the dichotomous choice is higher than for open-ended questions *(tables 3* and *4)*. Hoehn and Randall (1987) rigorously discuss the incentives and decision process of individuals in the two response formats. They show that the open-ended WTP response format is likely to yield estimates of WTP below that of dichotomous choice, which is more incentive compatible. Of course, it is possible that more conservative open-ended results are more accurate estimates of WTP. Without asking for actual cash payment to test the validity of the two question formats, we cannot say definitely which is most accurate.

Results of Hypothesis Tests

Given the expectations of the NOAA panel, respondents who had received version 2 and had been reminded about competing programs and their own budget constraint should have produced lower WTP estimates than those of respondents who had received version 1. However, the means of responses to the open-ended WTP questions are similar ($33 versus $36), and the confidence intervals overlap *(table 5)*. Thus, there is no evidence of a difference between responses to the open-ended WTP questions elicited from the two versions.

In the case of dichotomous choice CVM *(table 6)*, the estimates of WTP are also similar across the two versions ($92 versus $98). Testing the statistical significance of differences in dichotomous choice responses involves performing a likelihood ratio test, which tests the equality of the logit equation's slope and intercept for the two survey versions. If the

Table 6—***Bivariate logistic regressions by version***

Variable	Version 1	Version 2
Constant	1.048	1.482
(t statistics)	(3.720)	(5.050)
Bid	–0.015	–0.017
(t statistics)	(–3.760)	(–4.540)
Log-likelihood	–75.280	–73.880
Chi-square	23.309	32.917
Pseudo R squared	0.134	0.182
Mean willingness-to-pay (WTP > 0)	$91.57	$98.32
Median WTP	$71.28	$86.69

response behavior (e.g., slope and intercepts) is the same in the two versions, there should be no difference between the log likelihood value when the data are pooled i.e., the coefficients in equation 1 are restricted to being equal across the two versions) versus the sum of the separately estimated log likelihoods (i.e., the coefficients are allowed to be different across the two versions). The likelihood ratio test (LLR) is two times the difference in the pooled log likelihood value and the sum of the individual log likelihood value (–2[–149.85 – (–75.28 + –73.88)]). The test statistic has a chi-square distribution when the coefficients are not different across versions.

The pooled log likelihood is –149.85. As reported in *table 6*, the individual log likelihoods are –75.28 and –73.88. Given the fact that the sum of the two individual log likelihoods is nearly identical to the pooled value (–149.85 vs 149.16), it is not surprising that the LLR test for the bivariate logit equations produces a calculated chi-square of 1.36. This is well below the critical value at the 0.01 level of significance of 6.635. Thus we can say that no difference was detected in the response to dichotomous choice with the two different versions of the survey. This is consistent with what we found with responses to the open-ended WTP questions as well.

Discussion

There are several interpretations of the similarity of WTP responses across survey versions. The most optimistic is that respondents in a WTP framework already take into account their budget and expenditures for competing public and private alternatives when providing their WTP responses. This is similar to what Boyle and others (1990) found with regard to explicitly reminding respondents about substitute hunting opportunities. If we continue to find this in other studies, then there may be no need to remind respondents about competing public demands or their budget constraint as originally recommended by the NOAA panel.

An alternative interpretation is that when dealing with any hypothetical scenario, people do not seriously consider the real dollar consequences of their survey responses. Thus, the budget reminder statement does not modify behavior since the dollars to be paid in the survey are still hypothetical. Without a validity test forcing respondents to actually pay (Bishop and Herberlein 1979, Duffield and Patterson 1992), we cannot definitely distinguish between these two possible explanations. The fact that the bid amount has a negative coefficient, however, does indicate that households were less likely to pay the higher (hypothesized) dollar amounts.

A third interpretation is that, although participants understood the task, the dollar values were sufficiently vague and respondents with or without considering their own budget constraints could not distinguish a specific value. Thus their own unfamiliarity with the valuation process overwhelmed the finer distinction about considering their budget and competing needs.

In this case, subjects who were not used to thinking about a fire protection program in dollar terms may simply have been unable to sufficiently optimize their response (this is consistent with Hoehn and Randall [1987] for the open-ended responses), and thus the additional reminder about their household budget and other species was not used.

Multivariate Dichotomous Choice Results

Since the LLR tests indicate similarity of dichotomous choice WTP behavior across versions, we can safely pool the data for the two versions.

Doing so allows us to investigate the effect of other independent or explanatory variables on dichotomous choice WTP responses.

Table 7 provides the coefficients and t-statistics for this multivariate equation. As can be seen, all of the coefficients have the intuitively expected sign and are significant at the 0.05 level or higher. The pseudo R squared is 0.31, much higher than that in the bivariate model. The multivariate logit equation variables are the following:

Fire Harm: A person's perception of whether fire is harmful to diversity of plants and animals, health of trees, muddying of salmon spawning habitat, or Northern Spotted Owl habitat. Responses are –1 for "fire is beneficial," 0 for "fire has no effect," and +1 for "fire is harmful." Thus a score of +4 would be "fire is harmful to all," while a –4 would be "fire is beneficial to all." Scores close to zero indicate that fire has neither a positive or negative effect.

Existence Importance: The importance of knowing old-growth forests exist in Oregon. It is measured on a 1-to-4 scale, 4 being very important and 1 being not important.

Education: The level of education in years.

Forest Recreation: A dummy variable for whether participants had visited forests for recreation in the past 12 months; 1 if they have visited the forest, 0 if not.

Bid Amount: The dollar amount participants were asked to pay.

Income, age, and gender were not statistically significant. A statistically significant effect was not found for income even when education was excluded from the equation. This may be because the dollar amounts people were asked to pay were relatively small compared to their income or because in reality, there is no association of the response with income.

Figure 2 presents the logit curve derived from the multivariate logit model in *table 7*. The distribution is relatively symmetric and well-behaved. This is evidenced by the median (i.e., the 50th percentile) being \$81 while the mean is \$90. The median of \$81 allows for some people to be adversely affected by the fire program.

Expanding the Sample to the Population: Preliminary Estimates

When applying the results from the sample to the population, one critical concern is the external validity or generalizability of the sample values to the population. This is partly dependent on the representativeness of the sample frame and the survey response rate. While our sample frame was a random sample of Oregon's households, the response rate was a little lower than

Table 7—***Multivariate logit equation for data pooled across versions***

Variable	Coefficient	t-Statistic
Constant	–3.840	–3.93
Fire harm	0.308	3.79
Existence importance	0.409	2.46
Education	0.241	3.99
Forest recreation	0.717	1.98
Bid amount	–0.021	–3.94
Chi-square	102.465[1]	
Pseudo R squared	0.309[2]	

[1]There are 5 degrees of freedom for the chi-square (Kmenta, Jan. 1986. 2nd. ed., p. 556). He states, "Note that in general the number of degrees of freedom of the chi-square variable is given by the number of explanatory variables in the model."

[2]See Kmenta (1986). The computational formula is $1 - (LLF_{max}/LLF_{null})$ where LLF_{max} is the log likelihood function under the full model and LLF_{null} is the log likelihood function under the null hypothesis (all the B's set equal to zero).

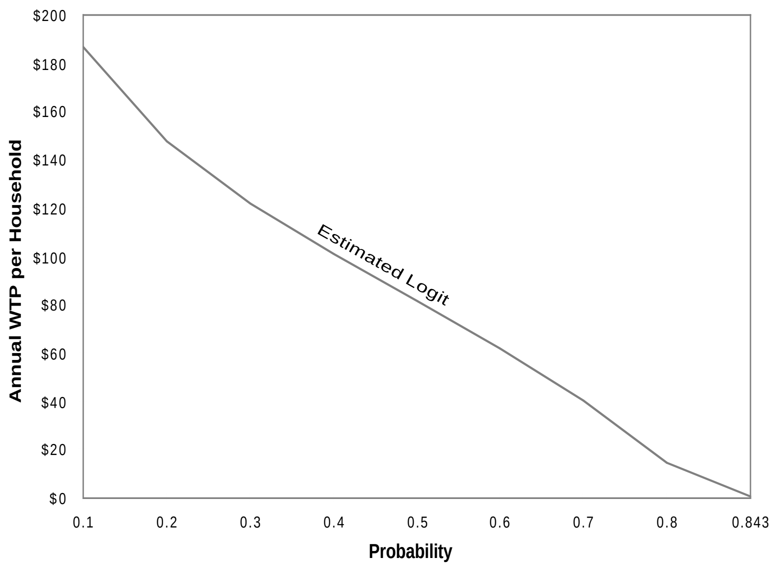

Figure 2—Oregon households' willingness-to-pay (WTP) function for prevention of fire in old-growth forests.

desirable. Our sample had about 1.3 years more education than the residents of the State of Oregon as a whole *(table 2)*.

Table 8 provides a range of benefit estimates based on three approaches to applying the sample results to the population. The first approach, sample average, generates a WTP of $90 per household and about $99 million annually by generalizing the sample average to the entire Oregon population. In this approach the sample average value is applied to nonresponding households as well. To generate a lower WTP estimate we assume that the proportion of households not responding to the survey holds a zero value for the fire prevention and control program. Since our sample response rate was nearly 50 percent, this means a value per household of $45 ($90/2) and a state aggregate value of $49.5 million annually. Finally, a medium estimate would be obtained by replacing the average education level of our sample, 14.3 years, with the average education level of the State of Oregon residents, 13.0 years, in our logistic regression equation *(table 7)*. This procedure attempts to make the resulting sample more representative of the State population using the only statistically significant demographic variable. The result provides an overall WTP estimate of $77 per household for the State of Oregon, which translates into $84.6 million annually for the old-growth forest fire prevention and control program.

All the above estimates should be recognized as preliminary, subject to further refinement. These values do not include any values that households in the other 49 states in the United States would place on reducing the risk of wildfire in Oregon's old-growth forest and spotted owl habitat. The United States population has about 100 million households, and Oregon has about 1 million households. Even if the rest of the households in the United States hold a much lower value toward fire protection in Oregon's

Table 8—*Applying the sample's willingness-to-pay to the State of Oregon*

Statistic	90 pct confidence interval	Mean WTP per household	Households	Total
			———*millions*	———
Sample average	$70-$111	$90	1.105	$98.920
Middle estimate (Adjusted for education)	$64-$96	$77	1.105	$84.588
Lower estimate (Zero for nonrespondents)	$35-$56	$45	1.105	$49.460

old-growth forests, the rest of the United States' value would likely dwarf the value held by just Oregon's residents. Respondents were told in the survey that the fire prevention and control program would reduce by half the number of acres of old-growth forests that would burn each year. This represents a reduction of 3,500 acres of old-growth forest that would no longer burn each year. If we take the middle WTP estimate of $84.6 million annually and divide it by 3,500 acres that would no longer burn, the resulting value to the public per acre saved from fire is $24,170. Additional reduction in acres burned would be valued less on a per-acre basis.

In terms of putting the values on a per-acre basis consistent with how economic values are used in USDA Forest Service National Fire Management Analysis System (NFMAS), we would divide the $84.6 million by the 3 million acres of old-growth forests in protected CHU's of Northern Spotted Owl. This results in a value to the public of $28 per acre protected.

Conclusion and Future Research

Overall, the survey was relatively successful in eliciting willingness-to-pay values for protecting old-growth forests in Oregon from wildfire. The survey did receive nearly a 50 percent response rate, and the WTP amounts from both open-ended and dichotomous choice were statistically different from zero. There was no difference between results from the two survey versions, leading us to believe that individuals took their budget constraint into account when answering WTP even without being reminded. This does not preclude different interpretations of the findings as presented in the section on Statistical Coefficients and WTP. The annual value per household in the sample was $90. Depending on how this is generalized to the State, the total annual Oregon residents' willingness-to-pay ranges from $49.5 to $99 million with a middle estimate of approximately $85 million annually. On a per-acre basis of old-growth forest protected from fire, this is $28.

The absence of well-documented statements that the fire prevention and control program would technically work may have contributed to the relatively high protest response to the willingness-to-pay question. Even so, many people indicated they were opposed to any new government programs. This opposition is a difficult issue that must be dealt with in future focus groups and survey pretesting. One possible strategy to use in dealing with this issue would be to identify those aspects of the fire prevention and control program that elicited this anti-government response, and determine how the program can be differentiated from other general government programs. Another possibility is to frame the forest protection effort as a private, local or nonprofit (i.e., not State or Federal government) fire prevention district or insurance program. For example, WTP could be asked as an annual insurance premium for the fire prevention and control program. Another more promising alternative is to conduct in-person interviews, so that respondents are clearly focused on the economic issue of the study.

Although demographics of the sample were similar across survey versions, they over-represented older, better-educated, and higher-income households. The sample also over-represented males. Only education was statistically significant in explaining WTP in the dichotomous choice logit regression. Therefore, in applying the result from the sample to the population, we accounted for the difference in education level of the sample and the State residents in our midlevel estimate of WTP. More representative demographics could be obtained in future surveys if the sample frame is generated from a more expensive random-digit dialing approach of all households.

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Appendix A — Survey Instrument

YOUR THOUGHTS ON OREGON'S OLD GROWTH FORESTS

Since the public's desired uses of Oregon's old growth forests have been changing we would appreciate your thoughts on how these forests should be managed. Your responses are completely confidential. **Please mail the survey back in the postage paid return envelope we provided.**

In this survey the term **old growth forest** means natural forests composed of a variety of trees of different ages but dominated by many large, old trees. These forests take about 200 years to regenerate following severe fire or cutting.

THE IMPORTANCE TO YOU OF OREGON'S OLD GROWTH FORESTS

Please circle the level of importance for each reason why you might care about old growth forests in Oregon.

Reasons you might value Old Growth forests	Not Important	Slightly Important	Important	Very Important
To be able to visit old growth forests in Oregon	1	2	3	4
To provide timber	1	2	3	4
To protect its plants & wildlife	1	2	3	4
To provide jobs	1	2	3	4
To know that old growth forests exist in Oregon	1	2	3	4
To protect the scenic beauty of Oregon	1	2	3	4

Appendix A — (continued)

THE EFFECT OF FIRE ON OREGON'S OLD GROWTH FORESTS

People often have differing opinions about the short term (1 to 5 years) effects of fires on old growth forests. Some people feel that fire is harmful, while others feel fire can have beneficial effects on old growth forests and its wildlife.

Please tell us whether you think fires have a harmful effect, no effect or a beneficial effect on the following natural resources or uses of Oregon's forests. Please check the box that best reflects your feelings.

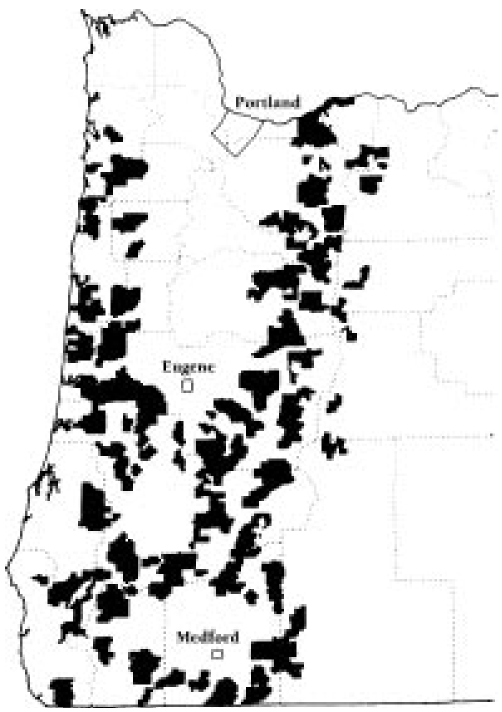
FIRE HAS…

RESOURCES/USES	A Harmful Effect	No Effect	A Beneficial Effect
Scenic beauty of forests	☐	☐	☐
Spotted Owl habitat	☐	☐	☐
Tourism	☐	☐	☐
Air quality	☐	☐	☐
Soil erosion	☐	☐	☐
Water quality	☐	☐	☐
Muddying of salmon spawning habitat	☐	☐	☐
Risk of floods	☐	☐	☐
Health of trees	☐	☐	☐
Recreational enjoyment of forests	☐	☐	☐
Fishing	☐	☐	☐
Diversity of plants and animals	☐	☐	☐

Appendix A — (continued)

OREGON'S OLD GROWTH FORESTS AND CRITICAL HABITAT FOR THE NORTHERN SPOTTED OWL

The **map** below shows the areas of U.S. Forest Service and Bureau of Land Management old growth forests in Critical Habitat Units that have been set aside from logging to protect the Northern Spotted Owl. In total this amonnts to about 3 million acres or one- third of western Oregon's Federal forests.



Spotted Owl Critical Habitat Units in Oregon

CURRENT NUMBER AND SIZE OF FIRES IN OREGON'S OLD GROWTH FORESTS

Currently, Federal forest management agencies spend several million dollars each year for fire prevention and control in Oregon's old growth forests. Even with this effort, an average of 300 fires occur per year in the Critical Habitat Units shown above These fires burn about 7,000 acres of publicly owned Critical Habitat Units. The area burned each year is e(lual to about 1,200 city blocks or 11 square miles, equivalent to an area 2 miles wide by 5.5 miles long. About half these fires are natural and half are caused by humans.

Many of these fires damage the old growth forests and decrease their ability to provide habitat for species such as the Northern Spotted Owl, salmon, and steelhead Fires also reduce recreation opportunities and scenic beauty of forests for many residents and visitors.

Appendix A — (continued)

DESCRIPTION OF FIRE PREVENTION AND CONTROL PROGRAM

Public land management agencies such as the U.S. Forest Service could reduce the number of acres of old growth forests and Spotted Owl hahitat that burn each year in Oregon. This program involves 3 parts:

1. GREATER FIRE PREVENTION: This includes more fire patrols maintenance of existing firebreaks surrounding these old growth forests, fire safety eductation and enforcement of fire regulations.
2. EARLIER FIRE DETECTION: This includes more flre lookouts and fire detection airplane flights.
3. QUICKER AND LARGER LIRE CONTROL RESPONSE: This requires having more firefighters and equipment located closer to the old growth forests in Oregon.

Adoption of this improved fire prevention and control program would on average reduce the number of acres of Critical Habitat Units that burn by half, a reduction of 3,500 acres a year (from 11 square miles to 5.5 square miles) on pubicly owned old growth forests in Oregon.

PAYING FOR THE FIRE PREVENTION AND CONTROL PROGRAM

Because Oregon's old growth forests are also Federally designated Critical Habitat Units for the threatened Northern Spotted Owl all U.S. households would pay into a special Oregon Old Growth Fire Control Fund. By law this fund could only be used to pay for fire protection in Federally owned old growth forests shown on the map. Adoption of this program would he decided as part of a national election.

YOUR CHANCE TO VOTE

1. Suppose this Oregon Old Growth Fire Prevention and Control Program proposal was on the next ballot. This program would reduce by half the number of acres of old growth forests in Critical Habitat Units that burn in Oregon each year. If it cost your household $__35___each year would you vote for this program?

(Please circle one) a. YES b. NO

2. What is the maximum your household would pay each year for the Eire Prevention and Control Program to reduce by half the number of acres of old growth forests in Critical Habitat Units that burn each year in Oregon? $________

Appendix A — (continued)

Answer Question #3 only if you said you would not pay anything, otherwise go to Question #4.

3. What was the main reason you said you would pay zero?

(Please check **only** the most important **one**).

____ This program is not worth anything to me.

____ I can't afford to pay at this time.

____ I don't think the program would work.

____ It is unfair to expect me to pay for this program.

____ I am opposed to any new government programs.

____ Other Reasons (Please explain) ____

____

____

Please go to the top of the next page.

4. Why would you pay your amount? (Please check **only** the most important **one).**

____ This program is worth at least this much to me.

____ I feel we have a duty to protect these old growth forests.

____ To contribute to a good cause.

____ To pay my fair share to protect the old growth forests.

____ Other Reasons (Please explain) ____

____

____

Appendix A (continued)

YOUR VISITS TO OREGON'S FORESTS

1. In the past 12 months have you taken any trips specifically for forest recreation such as picnicking, hiking, camping, fishing, bird watching, hunting, etc.?

YES NO

If YES, about how many trips have you taken in the last 12 months?

☐1-2 ☐3-4 ☐5-9 ☐10-14 ☐15-19 ☐20 or more

DEMOGRAPHICS

These last few questions will help us understand how well our sample represents the State of Oregon. Your answers are strictly confidential and will be used only for statistical purposes. You will not be identified in any way.

1. Are you: ☐male ☐female

2. What is your age? _____ # YEARS

3. Are you currently a member of a conservation or environmental organization?
YES NO

4. Did you make any donations or contributions for wildlife or environmental protection in the past year? (Please Circle)
YES, if YES About how much did you donate $ ______?
NO

5. Did you vote in the last presidential election?
YES NO

6. Please circle the highest number of years of education you have completed.

1 2 3 4 5 6	7 8 9	10 11 12	13 14 15 16	17 18 19 20 21
Elementary	Jr. High	High School	College or Trade	Graduate or Professional

7. About how much was your household income (before taxes) in 1992?

☐under $9,999	☐$10,000-14,999	☐$15,000-19,999
☐$20,000-24,999	☐$25,O0O-29,999	☐$30,000-34,999
☐$35,000-39,999	☐$40,O00-44,999	☐$45,000-49,999
☐$50,O0O-59,999	☐$60,O0O-69,999	☐$70,0OO-79,999
☐$80,OOO-89,999	☐$90,000-99,0O0	☐$100,000 +

THANK YOU VERY MUCH UOR COMPLETING THE SURVEY. PLEASE MAIL IT BACK TODAY IN THE STAMPED RETURN ENVELOPE.

If you have anything you would like to tell us about forest and wildlife management in Oregon feel free to write your suggestions on the hack of the survey

Appendix A — (continued)

Thank you for your participation!

Please add any additional comments here:

DECISION RESEARCH
1201 Oak Street
Eugene, Oregon 97401

Appendix B — Percent "Yes" responses by bid amount for the two survey versions

	Version 1			Version 2		
Bid	Yes	No	Yes	Yes	No	Yes
$	*no.*	*no.*	*pct*	*no.*	*no.*	*pct*
2	3	2	60.0	8	1	88.9
5	6	2	75.0	7	1	87.5
8	4	1	80.0	5	4	56.6
10	5	1	80.0	8	2	80.0
12	6	4	60.0	7	1	87.5
15	10	0	100.0	4	1	80.0
20	6	1	87.5	3	2	60.0
25	0	1	00.0	2	1	66.7
30	3	1	75.0	5	0	100.0
35	3	2	60.0	6	0	100.0
40	4	2	66.7	2	0	100.0
50	3	2	60.0	4	2	66.7
60	4	6	40.0	4	5	44.4
70	1	10	9.1	2	5	28.6
80	2	3	40.0	2	5	28.6
90	3	3	50.0	4	3	57.1
120	3	0	100.0	3	4	42.9
150	1	6	14.3	3	4	42.9
200	2	2	50.0	1	7	12.5
300	0	8	00.0	0	6	00.0

The Forest Service, U.S. Department of Agriculture, is responsible for Federal Leadership in forestry. It carries out this role through four main activities:

- Protection and management of resources on 191 million acres of National Forest System lands
- Cooperation with State and local governments, forest industries, and private landowners to help protect and manage non-Federal forest and associated range and watershed lands
- Participation with other agencies in human resource and community assistance programs to improve living conditions in rural areas
- Research on all aspects of forestry, rangeland management, and forest resources utilization.

The Pacific Southwest Research Station

- Represents the research branch of the Forest Service in California, Hawaii, American Samoa, and the western Pacific.

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ANALYSIS

Does clean air matter in developing countries' megacities? A hedonic price analysis of the Jakarta housing market, Indonesia

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ABSTRACT

Despite numerous hedonic studies on the value of clean air in developed countries, the lack of similar studies in less developed countries has raised the question as to whether clean air also matters in developing countries' megacities. As an attempt to fill this gap, we apply a hedonic property value analysis, the method commonly used to infer the value of clean air in developed countries, using the combination of data on housing rental prices and their characteristics from the Indonesian Family Life Survey, and data of the ambient level of six different pollutants in Jakarta, Indonesia. The result indicates that, in the cases of lead, total hydro carbon (THC), and SO_2, air pollutants have a negative association with property value; i.e., housing rental price. The relationship is at 5% level of significance for lead and 10% level for THC and SO_2. This paper estimates that per family value of clean air in Jakarta ranges from US\$28 to US\$85 per $\mu g/m^3$.

1. Introduction

Since the early 1990s, urban air pollution, particularly in megacities of developing countries, has been recognised as one of the world's major environmental concerns (UNEP and WHO, 1992; WRI et al., 1998). After a decade, nevertheless, environmental quality indicators still indicate that cases of severe urban air quality in developing countries continue to occur (World Bank, 2004). Clearly, there are serious difficulties involved in effectively implementing clean air policies in developing countries. One argument for this failure is that many governments in developing countries do not make an air pollution policy their top priority.

In the last few years in Indonesia, there has been growing concern, particularly among NGOs, that urban air quality has been at a disturbing level (MEB, 2002). The worst air quality is certainly in Jakarta, the largest city in Indonesia with a population of approximately 25 million, a population density of 14 thousand persons/km^2, and around 1.5 million cars and 2.5 million motorcycles daily on the streets. In various places in Jakarta in 1998, the levels of total suspended particles and nitrogen dioxide reached approximately 270 $\mu g/m^3$ and 148 $\mu g/m^3$, respectively, while the WHO allowable levels for these pollutants are 90 $\mu g/m^3$ and 50 $\mu g/m^3$. From these figures, Resosudarmo and Napitupulu (2004) estimated that the total health cost associated with pollutants in Jakarta was

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approximately 180 million USD or approximately 1% of Jakarta's GDP, or approximately as much as the total revenue of the Jakarta government for that year.

Since 2001, various NGOs have been able to lobby the Jakarta government to initiate a new clean air program to improve air quality significantly in the city. The new program mostly targets the reduction of air pollution from vehicles, hence includes activities such as the elimination of lead in gasoline, the implementation of an emission standard, improvement in public transport management and the adoption of strict emission inspection of vehicles (MEB, 2002). By 2003, lead was eliminated from the gasoline sold in Jakarta. However, the progress of other activities has been very slow; resulting still in a high level of air pollutants other than lead. One reason for this slow progress is that the Jakarta government has never made this air pollution policy one of its priorities.

The main goal of this paper is to elicit whether Jakarta residents care about and thus value cleaner air. In the current democratic Indonesia, where all regional government heads have been directly elected by people in their areas, regional governments are required to respond to the needs of their residents. Hence, if Jakarta residents care about and value cleaner air significantly enough, the Jakarta regional government may want to place air pollution policy as one of its priorities. This paper is hopefully not only useful for policymakers and environmental activists in Jakarta, but will also contribute to the more general debate as to whether or not people in developing countries are concerned about clean air, or environmental amenities, in general.

The valuation of environmental amenities, including clean air, is a complex area of research, because most environmental goods are non-marketed, hence their appropriate value cannot be easily identified (Freeman, 1993). There are basically two broad approaches to environmental valuation. The first is the direct approach that attempts to elicit preferences directly by the use of a survey and experimental techniques such as the Contingent Valuation Method (CVM) (Mitchell and Carson, 1989; Bjornstad and Kahn, 1996). The second is the indirect approach that seeks to elicit preferences from people's observed behaviour in the market; i.e. the preference of environmental amenities is revealed indirectly, when an individual purchases a marketed good (for example a house) related to the environmental good in question. Hedonic analysis is one technique in the category of indirect approaches (Rosen, 1974; Brown and Rosen, 1982; Georgiou et al., 1997). One of the advantages of the hedonic method is that it is observed actual behaviour of people in a real market that infers their valuation of the related commodities. In contrast, the hypothetical situation that could lead to much bias constrains the direct approach to valuation such as CVM from producing reliable inference from people's valuation (see also Arrow et al., 1993 and Carson et al., 2001 for comprehensive discussion of the strengths and weaknesses of the contingent valuation method). Hence this paper implements a hedonic analysis on housing rental value to elicit the value of clean air. The other motivations to do so are the following. First, whereas such studies are mostly of developed countries (Smith and Huang, 1995; Boyle and Kiel, 2001), this paper applies the technique to a developing country. In this regard, this paper is a rarity. Second, spatial data on the levels of six different air pollutants and data on housing rental values along with their characteristics, are available for Jakarta. This data makes it possible for this paper to combine a hedonic and a spatial analysis. Only a few studies have used this combined technique (Kim et al., 2003).

This paper is divided into 5 sections. Section 1 discusses the background of and motivation for this research. Section 2 presents the theoretical background of hedonic property value analysis and a short review of its relevant applications to air quality and housing value. Section 3 describes the estimation methodology and data. Section 4 provides a discussion of its result and its implications. Section 5 is the conclusion.

2. Hedonic property value studies and air quality

In this paper, we use hedonic price analysis to investigate whether or not air pollution affects property value – represented by housing rental price – and try to infer how much people are willing to pay for an improvement in air quality. Variability of air quality is an attribute of a house that may affect the willingness to pay (WTP) for the house as a whole. Hence, the structure of housing rents and prices will reflect these differentials. By using data on rent/prices of different properties we can in principle identify the contribution air quality makes to the value of the traded good, the house. This identifies an implicit or shadow price of these attributes, which in turn can be used to calculate willingness to pay for the non-marketed goods, namely air quality. The method commonly used to implement this approach is the hedonic technique pioneered by Griliches (1971) and formalised by Rosen (1974).

However, hedonic property value analysis suffers from theoretical and empirical problems. From the theoretical point of view, some strong assumptions, which are the foundations of this theory, are considered unrealistic by certain critics. The market clearing condition, for example, requires that the housing market is in equilibrium. It also requires a sufficiently wide variety of housing models to be available, such that every household is in equilibrium. Many consider this strong assumption to be the reason why applying this framework to the under-developed housing market in developing countries is hardly feasible. However, the Jakarta metropolitan area, being the Indonesian capital, has a relatively developed housing and property market, especially compared to rural areas of Indonesia. The housing market in Jakarta probably almost meets a market clearing condition. For example, a study by Struyk et al. (1990) on the Indonesian housing market mentions that the urban housing market in Indonesia is 'responsive to demand and flexible enough to changing conditions (p. 112)' and 'the rate of return on homeownership appears to be competitive with other alternatives (p. 82)'. These could be indications, though not necessarily, of a market clearing condition.

It is also important to note Freeman's argument (1993, p. 382–383): 'this idealized model is clearly not an accurate representation of real-world housing markets… [nevertheless] divergence from full equilibrium of the housing market in many circumstances will only introduce random errors into the estimates of marginal willingness to pay'. Hence, the imperfectness of the housing market condition is acknowledged but does not necessarily preclude the implementation of hedonic studies, as literature shows numerous hedonic studies, although not related to air quality, have been conducted. They are, to name a few, hedonic studies for the Philippines (Jimenez, 1984; North and Griffin, 1993); Thailand (Crane et al., 1997), Nigeria (Megbolugbe, 1989; Arimah, 1992a; Arimah, 1992b); Brazil (Aryeetey-Attoh, 1992), and Indonesia (Struyk et al., 1990; Crane et al., 1997; Yusuf and Koundouri, 2004; Yusuf and Koundouri, 2005).

There are also many practical problems in empirical works on hedonic property value analysis. They range from the definition and measurement of the dependent variable of the hedonic price functions, to its explanatory variables, correct or best functional forms, or identification problems.

There have been an enormous number of hedonic property value studies in an attempt to find out whether air quality is associated with property value, particularly in developed countries. Smith and Huang (1995) provided a formal summary of the hedonic studies for US cities from 1967 to 1988. Using a comprehensive meta-analysis of the hedonic property value model, this review of over 50 studies summarised that the marginal willingness to pay (MWTP) for one unit reduction of particulate matter lies between zero and US$ 98.52.

Boyle and Kiel (2001) is another study providing a more recent review of 12 hedonic studies for US cities. Table 1 (rows 1 to 12) presents the 12 studies surveyed by Boyle and Kiel (2001). The conclusion of this study is mixed; i.e. although most cases suggest that air pollution negatively and significantly affects property value, implying that people are willing to pay for air quality improvement, there are other cases showing that the effect might be not significant.

Whereas papers on the implementation of hedonic property value analysis in North America and Europe are relatively abundant, there are relatively very few for anywhere else; for example, there are two studies for Seoul—Korea and one for Taipei—Taiwan. (see the last three rows in Table 1.) Despite the importance and relevance of knowing whether or not and by how much people in poorer country value air quality, hedonic studies to infer the value of air quality in the developing world hardly exist (to our knowledge). It seems that the availability of consistent air pollution data is one of the main reasons. This study, then, will be among the few to apply hedonic price analysis to study the value of clean air in developing countries.

3. Methodologies and data

3.1. *Estimation methodology*

Since the theoretical underpinnings of hedonic analysis do not suggest a specific functional form, choosing the best one is merely an empirical question. To this end we employ a flexible functional form using the Box–Cox transformation model, the most common model used in hedonic price analysis (see

Table 1 – Summary of existing hedonic price studies related to air pollution

No[a]	Authors (publication year)	Study location	Pollutant(s)	Sign and significance
1.	Ridker and Henning (1992)	St. Louis, USA	Index of sulfation levels	Negative, significant at 5% level
2.	Wieand (1973)	St. Louis, USA	Suspended particulates	Negative, not ss[b]
			SO_2	Negative, not ss
			SO_3	Positive, not ss
3.	Deyak and Smith (1974)	Some US cities	Suspended particulates.	Negative, ss at 10% level
4.	Smith and Deyak (1975)	85 central US cities	Suspended particulates.	Negative, not ss
5.	Harrison and Rubinfeld (1978)	Boston, US	NO_2	Negative, ss at 1% level
6.	Nelson (1978)	Washington DC, USA	Particulate concentration, summer oxidant concentration	Negative, ss at 5% level
7.	Li and Brown (1980)	Boston, USA	TSP	Negative, not ss
			SO_2	Positive, not ss
8.	Palmquist (1982)	20 US cities	TSP, O_3, NO_2, SO_2	Mixed[c]
9.	Palmquist (1983)	14 US cities	TSP, O_3, NO_2, SO_2, and index of pollution	Mixed[d]
10.	Murdoch and Thayer (1988)	California, USA	Four indicator of visibility	All negative and ss at 10% level
11.	Graves et al. (1988)	California, USA	TSP, visibility	TSP is negative and ss at 5% level, but mixed for visibility
12.	Zabel and Kiel (2000)	4 US cities	NO_2, SO_2, TSP	23 of 80 coefficients are ss at 5% level, 19 of them are negative
13.	Kim et al. (2003)	Seoul, Korea	SO_2	Negative, ss at 5% level
			Nox	Positive not ss
14.	Yang (1996)	Taipei	TSP	Negative, significant at 5% level
15.	Kwak et al. (1996)	Seoul, Korea	TSP	Negative, significant at 5% level

[a] Rows No. 1 to 12 are adopted from Boyle and Kiel (2001).
[b] ss stands for statistically significant.
[c] Negative half the time for TSP and ss in 6 of the 20 TSP coefficients; all negative for NO_2 and ss in 8 of these 18 coefficients; all negative for ozone and ss in 8 of 12 these coefficients; 5 of 20 SO_2 coefficient negative and ss while 1 positive and ss.
[d] For index variable, the estimated coefficient was negative and statistically significant in six of the 14 cities in their study.

Cropper et al., 1999). The hedonic equation to be estimated is then,

$$y^{(\lambda)} = \alpha + \sum_i \beta_i x_{1i}^{(\lambda)} + \sum_j \gamma_j x_{2j} + \varepsilon \quad (1)$$

where

$$y^{(\lambda)} = \frac{y^\lambda - 1}{\lambda}; x_{1i}^{(\lambda)} = \frac{x_{1i}^\lambda - 1}{\lambda}$$

with α, β, and γ representing vectors of coefficients to be estimated, y the monthly rent of the house, x_{1i} the vector of variables to be transformed (i.e. size of the house, number of rooms, distance to district centre, and ambient level of 6 different pollutants), x_{2j} the vector of other non-transformed variables (dummy variables and variables that are not strictly positive and thus could not be transformed), and λ is the parameter of the transformation (functional form is linear when λ=1 and log-linear when λ=0), and ε is the error term. The model will be estimated using the Maximum Likelihood method (Greene 2000, pp.444–453; Haab and McConnell, 2002, pp. 254–256).

Many recent hedonic price studies suggest that in a cross-sectional hedonic price analysis, the value of a property in one location may also be affected by property values in other locations, such as in its neighbouring area (Dubin, 1988 and 1992; Geoghegan et al., 1997; LeSage, 1997; Bell and Bockstael, 2000; Leggett and Bockstael, 2000; Gawande and Jenkins-Smith, 2001; Kim et al., 2003; Brasington and Hite, 2005). Thus this paper will also check for the presence of this spatial effect. Where it is present, estimates of the hedonic equation could be biased in the case of a spatial-lag model (the dependent variable is affected by its spatial lags), and could be inefficient in the case of spatial auto-correlation (the error term is spatially correlated). This spatial analysis is summarised and reported in Appendix A.

3.2. Data

Data for the dependent variable (monthly house rent), structural characteristics, and neighbourhood characteristics are taken from the Indonesian Family Life Survey (IFLS) 1997–98, whereas data for air pollution variables are from a study conducted by the ADB (Syahril et al., 2003). The ADB study measured and reported concentrations of air pollution in Jakarta in 1998, almost at the same time as the survey of IFLS ended. The IFLS is a continuing longitudinal socio-economic survey, the first wave of which was conducted in 1993 (IFLS1). The second wave (IFLS2) was conducted from 1997 to 1998 (this dataset is freely downloadable from http://www.rand.org/labor/FLS/IFLS). The sampling scheme used for Indonesia as a whole was stratified by provinces, and then randomly sampled within provinces. Thirteen of the nation's twenty-six provinces were selected with the aim of capturing the cultural and socio-economic diversity of Indonesia. Within each of the thirteen provinces, enumeration areas (EAs) – the area of a village – were randomly selected, over-sampling urban EAs and EAs in smaller provinces to facilitate urban–rural and Javanese–non-Javanese comparisons. Finally, within each selected EA, households were randomly selected, producing around 7000 households to represent Indonesia as a whole. For this paper, a sub-sample of 470 observations from Jakarta province is used. This sub-sample represents the population of Jakarta, because of the nature of the provincial stratification of this sampling; i.e. the sample number from Jakarta is proportional to the population of Jakarta, not a result of random sampling across Indonesia.

Variables of the hedonic equations that are selected are those commonly used in the literature of hedonic property value analysis. The selection of variables also considers data availability. Monthly house rent (in Rupiahs) is used for the dependent variable in the hedonic equation. In hedonic studies, either the price or rent of the house is commonly used for dependent variables. Since the price or the value of the house is essentially the present value of its stream of rents, the choice between the two is not important. Structural characteristics that are included are the size of the house (in square meters); number of rooms; material for walls, roofs, and floors; and water source availability. Wall, roof, and floor materials are a dummy variable where we assigned 1 for better materials and zero otherwise. Those structural characteristics, hence, are expected to be positively associated with monthly house rent.

To represent the quality of the neighbourhood, some variables which are aggregated at the village level (or *kelurahan* level in the case of Jakarta) are selected. It is important to note that Jakarta is a city consisting of five districts (or *kotamadya*). Each kotamadya consists of several sub-districts or *kecamatan*. There are a total of 53 sub-districts in Jakarta. Each kecamatan consists of several villages or kelurahan. The unemployment rate (which is expected to be negatively associated with house rent) and the percentage of people in the village with a university education (expected to be positively associated with house rent) are proxies for the general quality of the neighbourhood. Accessibility of public transport (expected to be positively associated with house rent) and distance to the centre of Jakarta (expected to be negatively associated with house rent) attempt to measure the house's accessibility to employment.

Air quality is measured by the annual average ambient air concentration of six different pollutants i.e. PM_{10} (small particulates), SO_2 (sulphur dioxide), CO (carbon monoxide), NOx (nitrogen oxide), THC (total hydro carbon), and Pb (lead). The first two of these pollutants mainly come from fixed sources, whereas the rest mainly come from mobile sources. The ADB (Syahril et al., 2003) measured and reported the annual average concentration of air pollution, aggregated for 53 sub-districts (or kecamatan) of Jakarta. Measurements were based on the combination of direct measurement at the air quality monitoring station in Jakarta, and the (environmental) model which takes into account industry level, number/type of vehicles, traffic, wind direction, and meteorological data. For a more detailed discussion of air pollution data, please refer to the ADB publication (Syahril et al., 2003), which is available on the ADB web site.

The ADB (Syahril et al., 2003) also provided us with data on the yearly number of cars transiting a neighbourhood. We use this information as a proxy of the traffic congestion level. Using this variable as one of the explanatory variables is to ensure that pollution variables actually capture air quality, not the level of congestion. Table 2 provides a detailed description

Table 2 – Summary statistics of variables in the hedonic equations

	Mean	Std. deviation
Dependent variable		
Monthly rent (rupiahs)	838,735	9,509,536
Structural characteristics		
House size (m^2)	74.821	79.179
Number of room	5.306	2.793
Wall material is cement/brick (1,0)	0.783	0.413
Roof material is concrete (1,0)	0.004	0.065
Floor material is ceramic/stone (1,0)	0.294	0.456
Water source inside (1,0)	0.662	0.474
Neighbourhood characteristics		
Unemployment rate at the neighb. (pct)	1.465	2.492
People w. univ. educ. the neigh. (pct)	6.872	7.773
Accessible by public transport (1,0)	0.960	0.197
Distance to district centre (km)	6.561	4.485
Traffic (yearly number of vehicle passing)	234,265	81,546
Air pollution		
Ambient level of PM10 (mg/m^3)	92.439	23.361
Ambient level of SO_2 (mg/m^3)	22.879	8.627
Ambient level of CO (mg/m^3)	2,696.106	386.040
Ambient level of NOx (mg/m^3)	139.011	46.421
Ambient level of THC (mg/m^3)	319.844	84.916
Ambient level of lead (mg/m^3)	0.367	0.085

and summary of statistics of all variables used in the hedonic equation.

Combining the IFLS and air pollution data sets, however, raises one problem. The way pollution is measured and reported for every sub-district is not really accurate because pollution does not recognise administrative boundaries. Since there are many houses in a sub-district, air quality in one house may not be best represented by the air quality of the respective sub-district if that house is located near or at the border with another sub-district. These, among other, are sources of inaccuracy in the pollution variable, which is unfortunately unavoidable using the available data. To minimise the problem, we use a simple average of the pollution level around the neighbourhood as an indicator of air quality. A house located in sub-district A will assume the average air quality of sub-district A and its surrounding sub-districts. Intuitively, this averaging technique is analogous to the moving average or seasonal adjustment method commonly used for time series data, but this time in the spatial context. Seasonal adjustment, through the averaging process, will implicitly reduce the effect of measurement error (Hausman and Watson, 1983, p. 1).

4. Results and discussion

The main estimation result is presented in Table 3. First of all, this result suggests that the linearity and log-linearity of the hedonic equation variable is rejected. Parameter λ in the Box–Cox model is estimated to range from around −0.1570 to −0.1595, and is strongly significant at the 1% level across the six specifications. This may suggest that, in terms of goodness-of-fit (likelihood value), the flexible functional form is preferred.

House structural characteristics and neighbourhood qualities are strongly associated with house rent. This result is relatively consistent with the results of Yusuf and Koundouri's studies (2004 and 2005). Yusuf and Koundouri also implemented a hedonic model to the IFLS data, but covered the whole of Indonesia and focused on clean water provision. In all specifications, house structural characteristics; i.e. house size, number of rooms, wall and floor materials, are all positively associated (as expected) with house value and are significant at the 5% level. Only roof material is significant at the 10% level.

Three out of four neighbourhood characteristics conform to expectation, and are significant at the 5% level. The unemployment rate within the neighbourhood is negative and is significantly associated with house rent, whereas the percentage of people with a university education, and accessibility of public transport are positively associated with house values. Both are significant at the 5% level.

Distance to the centre of Jakarta, however, is not significant at a conventional level, and two reasons may account for this. First, it may not be a good measure of accessibility to employment. The better measure may be the distance to the centre of a district (or kotamadya in the case of Jakarta) where important business centres are located. The second reason is that the accessibility of employment might have already been captured by accessibility of public transport (which is positively significant).

The coefficient on traffic is significant at the 5% level. The positive sign of this coefficient, however, needs to be carefully interpreted. It may be argued that traffic not only represents the congestion level but also proximity to other city attractions. So these effects may oppose each other, and the latter seems to be stronger.

All of the coefficients of pollution variables, except PM_{10}, are negative, suggesting better air quality is associated with higher property value, and 3 out of 6 are statistically significant (10% for SO_2 and THC, and 5% for Lead). This result has a straightforward implication; i.e. it indicates that people in Jakarta are concerned with air quality. By calculating the marginal effect of a change in 1 unit of SO_2, for example, it can be interpreted that the capitalised marginal willingness to pay (MWTP) for a 'permanent' reduction of SO_2 concentration is around Rp. 275 thousand (Table 3). The formula to calculate the capitalised MWTP is as follows:

$$W = \sum_{t=0}^{25} (1 + r)^t (12 \cdot w) \quad (2)$$

where

W capitalised marginal willingness to pay; i.e. how much a household is willing to pay for a 'permanent' (typically 25 years) reduction of a unit of pollutant,

w marginal willingness to pay per month, i.e. marginal effect of hedonic equation,

r is discount rate of 5%,

t year.

Note that marginal effect is calculated as derivative of the rent in the hedonic price function with respect to its explanatory variable e.g. SO_2, and evaluated around the mean of all the explanatory variables.

Table 3 – Result of Box–Cox hedonic estimation (dependent variable: monthly rent)

Number of rooms	0.0625	0.0629	0.0614	0.0621	0.0613	0.0610
	(10.89)**	(11.93)**	(11.00)**	(10.84)**	(11.17)**	(10.84)**
Wall is cement/brick (1,0)	0.0810	0.0813	0.0791	0.0810	0.0816	0.0845
	(22.31)**	(23.68)**	(21.55)**	(22.10)**	(23.42)**	(24.39)**
Roof is concrete (1,0)	0.1640	0.1548	0.1583	0.1640	0.1525	0.1541
	(3.62)*	(3.42)*	(3.42)*	(3.60)*	(3.24)*	(3.24)*
Floor is ceramics/stone (1,0)	0.0672	0.0629	0.0671	0.0673	0.0640	0.0630
	(24.99)**	(23.04)**	(25.35)**	(25.01)**	(23.49)**	(22.03)**
Water source inside (1,0)	0.0302	0.0339	0.0323	0.0303	0.0351	0.0357
	(4.44)**	(5.72)**	(5.02)**	(4.44)**	(5.95)**	(6.09)**
Neighbourhood characteristics						
Public transport access (1,0)	0.0981	0.1101	0.1033	0.0983	0.1191	0.1236
	(8.85)**	(11.00)**	(9.66)**	(8.85)**	(11.71)**	(12.47)**
People w. univ. education (%)	0.0052	0.0051	0.0050	0.0053	0.0052	0.0055
	(39.10)**	(40.07)**	(35.90)**	(39.99)**	(40.88)**	(43.75)**
Unemployment rate (%)	−0.0067	−0.0064	−0.0061	−0.0066	−0.0056	−0.0053
	(7.34)**	(7.97)**	(6.72)**	(6.95)**	(5.62)**	(4.85)**
Distance to district center (km)	0.0072	0.0070	0.0049	0.0069	0.0036	0.0037
	(0.52)	(0.53)	(0.24)	(0.46)	(0.13)	(0.14)
Ambient air pollution (mg/m^3)						
PM10	0.0060					
	(0.01)					
SO_2		−0.0650				
		(2.80)*				
CO			−0.2498			
			(0.98)			
NOx				−0.0049		
				(0.01)		
THC					−0.1968	
					(3.15)*	
Lead						−0.0898
						(4.41)**
Constant	4.9275	5.0527	6.0606	4.9662	5.6452	4.8122
Lambda	−0.1572	−0.1595	−0.1578	−0.1570	−0.1585	−0.1575
s.e.	(0.02)**	(0.02)**	(0.02)**	(0.02)**	(0.02)**	(0.02)**
Log likelihood	−6,159	−6,157	−6,158	−6,159	−6,157	−6,156
LR chi-squared (11)	331.45	334.24	332.42	331.45	334.60	335.85
Capitalised marginal willingness to pay***		SO_2			THC	Lead
Rupiah		274,939			828,308	375,604
US dollar		28.34			85.39	38.72

Note: **Significant at 5% level. *Significant at 10% level. Variable in italics are not transformed.
Number in parentheses (except for lambda) is LR chi-squared statistics. Number of observation is 470.
***Calculated only for significant coefficients. See Eq. (2) for the formula used to calculate these numbers.

Boyle and Kiel (2001 p.120) in their survey of hedonic studies, report a few estimates of the dollar value of SO_2 concentration, ranging from US$58 to US$328 per μg/m^3. To make it comparable, the capitalised MWTP for SO_2 from this study is converted into 1997 US$, resulting in as much as US $28 per μg/m^3. Although certainly this is still far below the value people in developed country are willing to pay, it is a good indication that people in Jakarta may in fact be aware and also willing to pay to avoid living in a polluted area.

This study finds that the highest estimate of capitalised MWTP is for THC, which is approximately Rp. 828 thousand or US$85 per μg/m^3 (Table 3). Some caveat, however, is worth noting related to the estimate of MWTP. First, the coefficients of most of the pollution variables are only marginally significant; i.e. at a 10% level of significance. A much stronger conclusion can be made if those coefficients are significant at a 5% level. Secondly, a difficulty in interpretation may arise when trying to use the estimates to infer the MWTP for reduction in every pollutant due to the high correlation among different types of pollution variables.

It is important to note that, in this paper, we opt not to include all six of the pollution variables in one hedonic equation. The reasons are as follows. Firstly, we aim to avoid multicollinearity that may reduce the precision of the estimates, since cross-correlation among these pollutants is very high. Note that, in the context of a linear regression model, Yusuf and Koundouri (2007) show that an instrumental variable can be used to correct the attenuation bias in a pollution variable. However, since this paper applies a standard approach of flexible Box–Cox functional form which is non-linear, we do not implement the approach suggested by Yusuf and Koundouri (2007).

Secondly, since people may tend to care only about air quality in general and not specifically about a particular type of pollutant, it is more intuitive to use a single proxy for air quality (the pollution variable). Nevertheless, we did try to use a combination of one pollutant from a mobile source, and one from a fixed source, since people may know how close they are to sources of pollution. Because there are two distinct sources of pollution, i.e. mobile and fixed sources, people will take into account two different types of information in deciding where they live. For example, they will try to avoid living near factories and areas with heavy traffic. However, the result using this specification does not change any conclusion.

There are two main concerns regarding the quality of the estimation. The first is the possibility of omitted variable bias due to the possibility that it is the congestion level, not the air quality that is captured by the pollution variables. To deal with the former, data on traffic (i.e. the yearly number of vehicles passing through every area) is used to proxy the level of congestion. The model is re-estimated adding the traffic variable as one of the explanatory variables, and the result is shown in Table 4. The result suggests no sign of inconsistency in the estimators, since there is no significant change in the

Table 4 – Result of Box–Cox hedonic estimation (with traffic, dependent variable: monthly rent)

	1	2	3	4	5	6
Structural characteristics						
House size (m^2)	0.0362	0.0361	0.0415	0.0408	0.0397	0.0405
	(4.41)**	(4.81)**	(6.23)**	(5.57)**	(5.77)**	(5.93)**
Number of rooms	0.0648	0.0640	0.0613	0.0624	0.0620	0.0618
	(11.40)**	(11.81)**	(10.54)**	(10.44)**	(10.93)**	(10.70)**
Wall is cement/brick (1,0)	0.0860	0.0873	0.0837	0.0861	0.0870	0.0882
	(24.17)**	(25.68)**	(23.02)**	(23.55)**	(25.09)**	(25.30)**
Roof is concrete (1,0)	0.1565	0.1479	0.1438	0.1581	0.1465	0.1515
	(3.18)*	(2.96)*	(2.68)	(3.16)*	(2.83)*	(2.99)*
Floor is ceramics/stone (1,0)	0.0662	0.0617	0.0662	0.0669	0.0634	0.0633
	(23.44)**	(20.96)**	(23.53)**	(23.31)**	(21.75)**	(21.22)**
Water source inside (1,0)	0.0292	0.0339	0.0336	0.0297	0.0347	0.0341
	(4.02)**	(5.42)**	(5.20)**	(4.02)**	(5.49)**	(5.26)**
Neighbourhood characteristics						
Public transport access (1,0)	0.1087	0.1231	0.1223	0.1083	0.1302	0.1271
	(10.38)**	(12.87)**	(12.56)**	(10.10)**	(13.17)**	(12.60)**
People w. univ. education (%)	0.0058	0.0058	0.0056	0.0059	0.0059	0.0060
	(43.79)**	(45.45)**	(41.27)**	(44.63)**	(45.72)**	(46.86)**
Unemployment rate (%)	−0.0052	−0.0045	−0.0031	−0.0046	−0.0037	−0.0040
	(4.01)**	(3.23)*	(1.34)	(2.84)*	(2.08)	(2.47)
Distance to district center (km)	0.0022	0.0009	−0.0053	0.0008	−0.0023	−0.0003
	(0.05)	(0.01)	(0.23)	(0.01)	(0.05)	(0.00)
Traffic	0.0889	0.0883	0.1102	0.0822	0.0826	0.0671
	(5.33)**	(5.79)**	(7.69)**	(4.86)**	(5.07)**	(3.16)*
Ambient air pollution (mg/m^3)						
PM10	0.0611					
	(0.53)	(0.00)				
SO_2		−0.0774				
		(3.78)*				
CO			−0.5376			
			(3.86)*			
NOx				−0.0172		
				(0.06)		
THC					−0.2071	
					(3.41)*	
Lead						−0.0747
						(2.76)*
Constant	4.4495	4.7973	7.0062	4.7451	5.4233	4.6210
Lambda	−0.1554	−0.1568	−0.1552	−0.1544	−0.1559	−0.1553
s.e.	(0.02)**	(0.02)**	(0.02)**	(0.02)**	(0.02)**	(0.02)**
Log likelihood	−6,156	−6,154	−6,154	−6,156	−6,155	−6,155
LR chi-squared	336.78	340.03	340.11	336.31	339.66	339.01
Marginal willingness to pay***		SO_2	CO		THC	Lead
Rupiah		326,229	2,264,205		869,293	312,324
US dollar		33.63	233.42		89.62	32.20

Note: **Significant at 5% level. *Significant at 10% level. Variable in italics are not transformed.
Number in parentheses (except for lambda) is LR chi-squared statistics. Number of observation is 470.
***Calculated only for significant coefficients. See Eq. (2) for the formula used to calculate these numbers.

value of the coefficients. It even turns out that CO is now significant at a 10% level, adding one more significant pollution variable.

The second is the potential presence of spatial effects. Ignoring the presence of spatial effect or spatial dependence may cause the simple OLS estimation to be either inconsistent or inefficient (Anselin, 1988). Hence we also conduct spatial analysis by estimating a spatial dependence and spatial error model, and this is discussed in more detail in Appendix A. The result does not suggest the presence of any spatial effect.[1]

As far as the motivation for this paper is concerned, however, it could be concluded that the claim that environmental amenities (in this case air quality) does not have value in developing countries is not supported by this study. Moreover, this paper may be one of the first attempts to use hedonic price analysis to study air quality in developing countries, which potentially could give comparable estimates of the willingness to pay for clean air.

5. Conclusion

This paper is an attempt to elicit the value residents of Jakarta place on cleaner air and to contribute to the debate as to whether or not the Jakarta regional government should make an air quality policy one of their top priorities. The main assumption in this paper is that if people do care about air quality in the area where they live, it must be an important attribute of their houses. Hence, a hedonic property value analysis can be used indirectly to infer people's preference concerning air quality from the price they pay for their houses.

It must be admitted that the main weakness of this paper is the data on air pollution. However, the existence of this data is progress of a sort, since the non-existence of air pollution data has prevented similar hedonic studies in developing countries. Firstly, measuring air quality in Jakarta as conducted by Syahril et al. (2003) is a relatively new activity. There has not been any debate as to whether or not the approach taken by Syahril et al. (2003) can really produce reliable data on spatial air quality. Secondly, the unit of the air pollution data is an annual average concentration of an air pollutant covering a sub-district area. This information might not accurately represent the severity of air quality in several locations in a sub-district for a particular season, which is actually an important factor in determining housing rental value in such locations. Meanwhile for several other locations, an annual average concentration of air pollutant covering a sub-district area might overestimate the air quality around these areas. Thirdly, as already mentioned while describing the data set, several house owners, particularly those on the periphery of a sub-district, might consider that their air quality is a combination of that of their own sub-district and that of the adjacent sub-district; i.e. the definition of a neighbourhood for an individual might not coincide with the boundary of a sub-district. Fourthly, the time periods when the IFLS household data and the data of the air quality were collected do not exactly match.

In the estimation we did include the yearly number of cars traversing a neighbourhood as a proxy of traffic congestion and to avoid the occurrence of an omitted variable bias. However, there is a possibility that our result still suffers from an omitted variable bias; i.e. there are other variables that can be correlated with measures of concentration of pollutants that are not included in the hedonic regression.

Bearing in mind all these weaknesses, several points might be noted from the empirical exercises in this paper. First, the empirical results indicate that air pollutants have a negative association with property value; i.e. housing rental price. In the cases of lead, total hydro carbon (THC), SO_2, and CO, the relationship is negative and significant. This finding suggests that Jakarta residents do care about and thus value cleaner air. It is estimated that per family value of clean air in Jakarta ranges from US$28 to US$85 per $\mu g/m^3$. The Jakarta regional government, which is directly accountable to the people in Jakarta, must respond to the fact that residents of Jakarta care about and value cleaner air by considering air quality policy one of their priorities.

Second, the empirical result of this paper may also imply that any effort to reduce air pollution in Jakarta, as long as it does not outweigh its appropriate financial cost, can be welfare-enhancing. This paper certainly supports the recent implementation of policy to phase out lead from gasoline used in Jakarta. It remains a puzzle why efforts to reduce other air pollutants do not progress smoothly in Jakarta. Further research on this topic would certainly be valuable.

Appendix A. Spatial analysis

More recently, many hedonic price studies suggest that in a cross-sectional hedonic price analysis, the value of a property in one location may also be affected by property values in other locations, such as in its neighbouring area. Ignoring this spatial effect or spatial dependence may cause the simple OLS estimation to be either inconsistent or inefficient (see Anselin (1988) for text-book treatment of spatial econometrics). In this paper, the presence of this spatial effect is tested, and treatment procedures will be carried out if needed.

In general, there are two classes of model developed to attenuate the problems of spatial effect, namely the spatial lag model and the spatial error model. In the former, house rental price not only depends on its characteristics but also on neighbouring house rental prices. The spatial lag model is an appropriate tool when capturing neighbourhood spillover effects. It assumes that the spatially weighted sum of neighbourhood housing prices (the spatial lag) enters as an explanatory variable in the specification of housing price formation, or

$$\tilde{\mathrm{P}} = \rho \mathbf{W} \tilde{\mathrm{P}} + \mathbf{X}\beta + \varepsilon \tag{A1}$$

where ρ is the spatial dependence parameter and $\mathbf{W}$ is an $n \times n$ standardised spatial weight matrix (where n is the number of observations). The spatial weight matrix, $\mathbf{W}$, tells us whether

[1] The other concern is actually about a measurement error problem in pollution variables. However, it is difficult to detect this issue and to correct it in the framework of a non-linear Box–Cox transformation estimation. Hence, it is beyond the scope of this paper.

any pair of observations are neighbours. If, for example, house i and house j are neighbours then, $w_{ij}=1$ and zero otherwise. Whether or not any pair of houses is neighbouring is either determined by them sharing common borders (contiguity) or based on a certain distance between them.

The spatial weight matrix is usually standardised, such that every row of the matrix is summed to 1. This enables us to interpret the spatial lag term in a spatial model as simply a spatially-weighted average of neighbouring house prices, for example, $P_1 = \rho(w_{12}P_2 + w_{13}P_3 + w_{16}P_6) + \sum_{j=1}^{k} \beta_j x_j + \varepsilon_1$, where observation 2, 3, 6 are neighbours of observation 1. The OLS estimation in the presence of spatial dependence will be inconsistent, because of the endogeneity problem. The spatial lag model will be estimated using maximum likelihood estimation (see Anselin, 1988, for detail MLE method).

The spatial error model takes the following form

$$\tilde{P} = \mathbf{X}\beta + \varepsilon;\ \varepsilon = \lambda\mathbf{W}\varepsilon + \mathbf{u} \tag{A2}$$

where $\mathbf{u}$ now is the i.i.d error term, and λ is the spatial error parameter. The OLS estimation of the spatial error model will be inefficient (Anselin, 1988) because it violates the assumption of the independence among disturbance terms.

In implementing the spatial analysis, we use both contiguity and distance to define the $\mathbf{W}$ matrix. To test the existence of spatial dependence, we conducted a statistical test to see whether ρ in Eq. (A1) (the spatial dependence model) is equal to zero. With H_0: $r=0$, and H_a: $\rho\neq0$, the statistics follow χ^2 distribution with 1 degree of freedom; we fail to reject the null and conclude that no spatial dependence is present in the model. A similar test is used for the presence of spatial autocorrelation, or testing whether λ in Eq. (A2) is equal to zero. Again, the presence of spatial autocorrelation is rejected. In short, our exercises do not provide evidence of spatial effect; i.e. the value of a property in one location is not affected by the property value in other locations. Results of our spatial analysis are available upon request.

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Annex 4: Checklist of Questions for Appraising a Public Investment Project Proposal on the Basis of Feasibility Study

1. Clarity of objectives

1.1 Are the project rationale, background, policy context and strategic fit covered in the Feasibility Study and clearly explained and justified?

1.2 Are the objectives consistent with the strategic aims and ultimate objectives as set out in, for example, ministerial programs and statements of government policy?

1.3 Does the proposal focus on outputs (generally services to the public), as opposed to inputs, and how these outputs contribute to the specified project purpose and ultimate goal?

1.4 Are the objectives - outputs, purpose and goal - defined in specific and measureable terms and with deadlines so that their subsequent achievement can be evaluated?

2. Choice and definition of alternatives

2.1 Is the range of project alternatives being considered wide enough, paying sufficient attention to, for example: quantity or quality of outputs/services; timing or phasing of investment; location of investment? Has the do-nothing (or do-minimum) alternative been explicitly considered?

2.2 Have any potentially promising alternatives been ruled out before detailed appraisal on the grounds of technical feasibility or other constraints (e.g. legal, political or financial)? If so, is the justification clear or could these constraints be questioned?

2.3 Can any of the project alternatives be split into independent components for separate appraisal? (A proposal may have separable components which provide much better value than others.)

3. Estimation of costs and benefits

3.1 In estimating the costs and benefits of the project, has account been taken of:

- Capital (including physical contingencies) and operating costs, staff costs (including overhead costs), maintenance, administration fees, rates etc.?
- Other costs and benefits which can be valued in money terms e.g. cost savings, non-marketed impacts?
- Quantified measures or at least descriptions of those costs and benefits which cannot be easily valued in money terms?

3.2 If certain costs or benefits are not quantified in monetary terms is this appropriately justified?

3.3 Are there any decisive unquantified costs or benefits and are these clearly explained?

4. Economic valuation of costs and benefits

4.1 Have all costs and benefits of the project been expressed in constant prices and discounted at the appropriate rate? Has account been taken of any relative price effects where they may be important?

4.2 Have costs been properly estimated? For example:

- Opportunity/resource costs used to value goods?
- Sunk costs omitted, but opportunity cost of already-owned assets included?
- Residual values included for long-lived project components?

4.3 Have adjustments been made to exclude transfers from economic values: (i) indirect taxes; (ii) subsidy payments excluded from economic values?

4.4 Have financing items and sources been excluded from cash flow analysis?

4.5 Are second-round effects properly justified and has double-counting of costs or benefits been avoided?

5. Economic analysis

5.1 Have the results of each project alternative been presented clearly, including the do-nothing (or do-minimum) alternative?

5.2 Is the time period for the socio-economic cost-benefit analysis long enough to encompass all important costs and benefits? Or has adequate account been taken of subsequent costs and benefits? Is the timing of all costs and benefits clear for each alternative?

5.3 Have the net present value (NPV) and/or economic internal rate of return (EIRR) been calculated? Do results of the economic analysis indicate that the project is economically feasible, meaning that the NPV is positive or the EIRR is above the prescribed minimum rate of return for public sector investment?

5.4 Are the results of the economic analysis robust in the face of more pessimistic assumptions concerning key values (as examined in sensitivity tests) and the worst-case scenario?

5.5 If monetary values cannot be estimated for economic benefits has a cost-effectiveness analysis been performed? Does the cost-effectiveness analysis confirm that the selected alternative has the lowest present value of costs per unit output compared to other project alternatives? Is there a strong qualitative case made for the economic benefits? Do the results of multi-criteria analysis lend strong support to the case for the investment in the capital project?

6. Assessment of project risk and uncertainty

6.1 If forecasts have been used are these reliable and what is their likely degree of accuracy?

6.2 Have all important risks and uncertainties been identified for each project alternative and assessed - either qualitatively or quantitatively?

6.3 Have key assumptions been identified and either considered reliable or treated as a risk for monitoring and mitigation?

6.4 Has appropriate sensitivity analysis been used, including a worst-case scenario? Are other methods of risk assessment also appropriate?

6.5 Is ongoing monitoring of risks and appropriate risk mitigation included in the budget and activity plans?

7. Financial analysis

7.1 If the project is commercial or has revenue-earning potential is there still a case for a budget capital subsidy? If budget funding for capital investment is justified, will the operating entity nevertheless be able to generate sufficient financial resources to cover operations and maintenance?

7.2 What are the impacts of the project on the income-expenditure account, balance sheet and cash flow of the operating entity? Will the project contribute to the financial objectives of the operating entity, taking account of proposed budget subsidies for capital investment?

7.3 If the project is to be financed from multiple sources, is the funding from sources other than the budget likely to be secured?

7.4 Has the overall impact on the public finances been assessed separately from the economic analysis, including any contingent liabilities or state guarantees?

8. Implementation management and operational analysis

8.1 Does the project have the characteristics that recommend consideration of procurement through a public-private partnership arrangement and, if so, has this option been investigated or highlighted for further consideration, including value for money analysis.

8.2 Is the project proposal practically deliverable and are there well-defined and realistic delivery plans with clear delivery dates and implementation milestones for monitoring purposes?

8.3 Has responsibility been clearly allocated for project outputs and expenditure?

8.4 Have operational requirements, such as staff and accommodation, been identified and budgeted?

8.5 Does the implementing organisation have the capability to develop itself or procure the proposed project outputs?

8.6 Is implementation of the project compatible with other projects and workloads being undertaken by the implementing organisation?

8.7 Are the assigned responsibilities, mix of skills and decisiveness of the project steering group appropriate to the project’s risks?

8.8 Will adequate financial and human resources be available for project rollout, handover and operations?

9. Environmental and Social Consequences

9.1 Have the major environmental and social consequences of the project been properly identified and appropriate mitigation measures designed where required?

9.2 Taking account of any proposed mitigation measures, has sufficient evidence been provided to indicate that the project will be environmentally sustainable?

9.3 Taking account of any proposed mitigation measures, has sufficient evidence been provided to indicate that the project will be feasible from a social perspective?

10. Presentation of results

10.1 Have the results been clearly presented? Is it clear who will benefit and who will bear the cost of each project alternative?

11. Monitoring and Evaluation

11.1 Does the project plan include satisfactory implementation monitoring arrangements – who, when, how, costs?

11.2 Does the project plan include clear proposals for evaluating project performance once the project is operating - who, when, how, costs?

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