SOURCES OF FINANCE FOR PROJECTS

1. **Financed by central government.**
   - revenue from taxation
   - money lent to savings schemes e.g. national savings, premium bonds, etc
   - profits (?) from state owned concerns
   - money borrowed from the international market
   - money raised by selling national assets

2. **For local government projects**

- revenue from rates
- money borrowed from investors (e.g. local government stock)
- money from central government

3. **For private schemes**

- retained profits
- equity investment
- debt finance (e.g. bank loans)
- government subsidies and investment through development agencies etc.

COST ESTIMATING

REASONS FOR COST ESTIMATING

PROJECT EVALUATION

PROJECT SELECTION

SELECTING CONTRACTORS AND SUPPLIERS

AS A MEASURE OF QUALITY

BUDGETING

PROJECT MANAGEMENT

Cost estimating is also used in procurement;

1. To obtain a fair price.
2. To ensure the quality of bought goods.
3. To ensure delivery according to schedule.

Cost Estimates are also used for:-

Deciding whether projects should proceed from stage to stage.

Forecasting the funding required by an organization.

Producing budgets against which expenditure may be monitored.

For work authorisation and cost control.

Cash Flow planning.

Evaluating alternative designs.

Some Other Purposes of Cost estimating

To assess:-

The effects of changes

The progress of a scheme

CLASSIFICATION OF ESTIMATES

Type of Estimate	Accuracy	Application
Order of Magnitude	With a factor of 10	Limited
Ball Park	± 25%	Initial Study
Comparative	± 15%	Initial Study
Feasibility	± 10%	Feasibility Study
Definitive	± 5%	Final Planning

COST ESTIMATING METHODS

1. Objective Methods

2. Subjective Methods

1. **Objective Methods** - need historical data

i) Synthetic methods

ii) Analogy method (also called comparative)

iii) Parametric or statistical methods.

2. Subjective methods

- rely on an estimator's recall of other projects.

They depend on how an estimator perceives the project, and its predecessors.

- are prone to error as a result of psychological and behavioural factors.

LESS ACCEPTABLE METHODS

1. "Price to win" estimates - rely on estimates or "information" (could be misinformation).

2. "Parkinsonian" estimates - based on the idea that work expands to fill the time available.

   "The product must be launched by April".

   "That gives us 6 months."

   "O.K. The job takes 6 months and our costs are £20,000 a month, so £120,000 in total”.

1. **OBJECTIVE METHODS**

i) Synthetic methods.

Work can be broken down into very elemental parts e.g. hand movements - reaching, grasping, placing which are used repeatedly.

- standard times can be build up using a pre-determined time for these motions.

- it is expensive and time consuming to collect such data.

- consultancy firms will supply data and/or do the necessary calculations (it's expensive!).

(1.**OBJECTIVE METHODS (cont))**

Advantages

Even for the newest tasks, many or all elemental parts will have been undertaken previously, so cost and time data are available.

Disadvantages

- a very detailed knowledge of the tasks is needed.
- it is easy to overlook a work element.
- elements are looked at in isolation. - costs may be incurred to combine the elements or because of the interaction of elements.

(1.**OBJECTIVE METHODS (cont))**

ii) **Analogy (or Comparative) Methods**

- Involves comparing the current project with those carried out previously.
- They have to be similar - but how similar is similar ?!
- Can be used in top down or bottom up estimating.
- Based on real experience.
- Databases of costs are available for some types of projects.

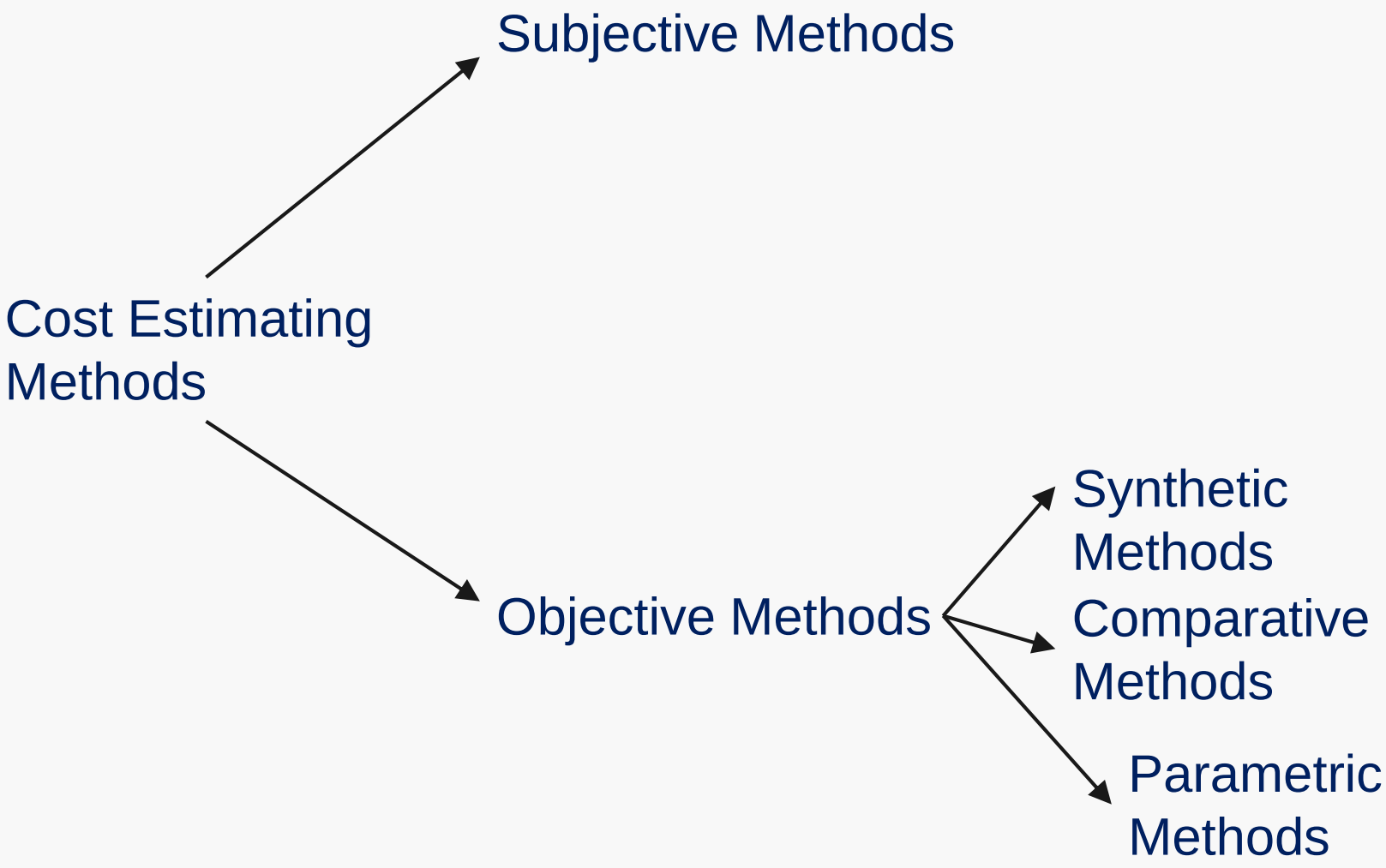
(1.**OBJECTIVE METHODS (cont))**

iii) **Parametric (or Statistical) Methods**

- Rely on the physical and/or technical characteristics of a project.

- Mathematical models are constructed based on data from previous projects.

Summary of the methods of Cost Estimating



Cost Estimates

can also be categorised as;

1. "Top Down" estimates.

2. "Bottom up" estimates.

Bottom Up Estimates

Steps in Bottom up estimating

1. The project is broken down into its component parts.

2. The cost of each component is estimated.

3. These costs are summed up to give the estimated project cost.

Advantages of Bottom up estimating

- can identify low level problems.
- detail can be used to justify the estimate.
- estimating errors for component parts may cancel each other out.
- experts on particular jobs can produce an estimate.

Disadvantages of Bottom up estimating;

- component parts may be overlooked.
- projects have to be well defined.
- management and administrative costs may be overlooked.
- require more effort than top down.
- the estimate may be subject to some "adjustment" as it passes up the organisational structure to the project manager.

Top Down Estimating

An overall cost for a project is derived from its global properties;

and then broken down into the various components of the project.

Advantages of Top down estimating

- can be applied at an early stage of project definition, when the lower levels of work breakdown have yet to be defined.

- costs of smaller parts will not be overlooked.

- cost of integrating parts will be included.

Disadvantages of Top down estimating

- does not identify low level problems, which can escalate costs.

- little detail for justifying the estimate.

- may be more prone to error than bottom up (component parts cannot cancel each other).

Suitable estimating methods at different stages of a project

Stage	Subjective method	Comparative method	Synthetic method	Parametric method
Feasibility	↓	↓		↓
			↓	
Full development and manufacture				

All forms of estimating - to a lesser or greater extent - include a degree of subjectivity.

Least amount - synthetic methods

Most amount - comparative

Subjectivity plays a part in;-

1. Selecting previous projects which are similar enough to the one under consideration.

2. Deciding how far back in time information is relevant to a new project.

3. Deciding whether the number of similar projects is sufficiently large to be considered frequent.

4. Deciding on factors which can be used as cost drivers in parametric estimating.

5. Collecting data on previous projects.

Even good empirical data can be biased.

- They cover only projects which were in fact carried out.

and were

1. As successful as anticipated.
2. More " than "
3. Less " " "

BUT DO NOT INCLUDE DATA FOR <u>REJECTED</u> PROJECTS WHICH COULD ALSO BE;

1. As successful as anticipated.
2. More " than "
3. Less " " "

<u>THIS PROBLEM CANNOT BE OVERCOME</u>

Cost Estimating Methods (continued)

Statistical methods

Estimating relationships

Linear: $Y = A + Bx_1 + Cx_2 .....$

Exponential: $Y = Ax_1^B . x_2^C .....$

Statistical or Parametric methods are a ***Management Science*** approach to estimating costs or durations as it applies data collection and mathematical modeling.

Examples of Simple Parametric Models

1. Estimating the cost of motoring in pence per mile.

   - no two motorists will run their cars in the same way.

2. Estimating the cost of a building from its floor area e.g. a particular type of industrial building may cost £200 m $^{-2}$ - but no two buildings will have precisely the same cost per m^2

3. Estimating the cost of designing and developing a gearbox in terms of its estimated weight.

4. Estimating the cost of a suite of computer programs in terms of the number of source instructions

   - even though coding may be less than ½ the total effort of the project.

Each of these examples has only one variable - known in parametric estimating as a cost driver - but more complex relationships can be found.

e.g. the cost of a building may be a function of the amount of land it occupies, the construction method, and its materials, as well as its floor area.

Parametric models can generally be classified as commercial or company developed.

Complex parametric models may consist of many interrelated Cost Estimating Relationships (CERs), as well as other equations, ground rules, rules of thumb, assumptions, and variables that describe and define the situation being studied.

Models generate estimates based upon certain input parameters, or cost drivers.

Parameters “drive the cost” of the end product or service being estimated.

Examples are weight, size, efficiency, quantity, and time.

Some models can develop estimates with only a limited set of descriptive program inputs; others, however, require the user to provide many detailed input values before the model can compute a total cost estimate.

A model can utilize a mix of estimating methods, and it may allow as inputs estimates from other pricing models (or information systems) or quotes from external sources, such as subcontracts.

Commercial parametric estimating models, use generic algorithms and estimating methods which are based on a database that contains a broad spectrum of industry-wide data.

As this data is drawn from many different products, a company working with a commercial parametric model must calibrate it before using it as a basis of estimate (BOE) for proposals submitted to the Government or higher-tier contractors.

Calibration tailors the commercial model so it reflects the products, estimating environment, and business culture of that particular company.

A proprietary model offers an alternative to trying to use a commercial model to meet an organization’s unique estimating requirements.

Proprietary models are developed for an organization’s own product and cost estimating needs and are, in effect, self-calibrated.

Essentially, a parametric estimate is determined by identifying the unit cost or duration and the number of units required for the project or activity.

The measurement must be scalable in order to be accurate.

For example, if it took someone two hours to mow one acre of grass last week and this week the person is mowing four acres, I could estimate that it will take eight hours to mow.

However, if the first one hour was spent transporting the mower and preparing it to mow, the estimate would need to be scaled appropriately: 1 hour for transporting and then four hours to mow, for a total of five hours.

Another Example

You are the project manager for the annual Earth Day 5k road race, with three primary components: marketing, registration, and race-day coordination.

For marketing, there will be 500 flyers printed up at a cost £0.20 each.

It took two weeks for the flyers to be printed for last year event, so you estimate two weeks for the printing of the brochures for this event.

Last year it took one week to design the on-line registration form and the cost to host the registration website was £850.00 You estimate the same this year.

There will be four people used to coordinate the race. Each resource will be paid £25 per hour and they will be working an estimated seven hours, based on the race last year.

Marketing

Cost: £100 for brochures

(parametric estimating 500 x £0.20)

Duration: two weeks

(analogous – the same as last year)

Registration

Cost: £850 (analogous – the same as last year)

Duration: one week

(analogous – the same as last year)

Coordination

Cost: £700 (parametric estimating - 4 x £25 x 7)

Duration: 7 hours (analogous)

Problems of Parametric estimates

The previous example (the cost of a building) derives a CER with four unknown parameters and the CER can be solved using simultaneous equations if there are four sets of data.

When there are more sets of data than unknown parameters then regression methods are used. (**Ref: Stanford Weisberg, Applied Linear Regression, Wiley, 1980**).

Similarities between analogy and parametric estimating:

Can be used for both duration and cost estimating
Essentially a combination of historical information (leveraging past projects/activities) and expert judgment

Differences between analogous and parametric estimating:

Analogy estimating is considered “top-down” and is less accurate than parametric. Analogy estimating uses an “analogy” i.e. comparing a past similar project to your current project.

Parametric estimating can be more accurate, specifically when the underlying data is scalable. Parametric estimating uses a relationship between variables (a unit cost/duration and the number of units) to develop the estimate.

Examples of effort (in Man Months (MM)) estimating models for estimating the cost of computer software.

$MM = 5.2\ KDSI^{0.91}$	Waltson-Felix, 1977
$MM = 4.9\ KDSI^{0.98}$	Nelson, 1978
$MM = 1.48\ KDSI^{1.02}$	Freburger-Basili, 1979
$MM = 2.4\ KDSI^{1.05}$	Boehm, 1981 (COCOMO, Organic Mode)
$MM = 5.3\ KDSI^{1.06}$	Herd and others, 1977
$MM = 2.43\ KDSI^{1.18}$	Frederick, 1974
$MM = 0.99\ KDSI^{1.275}$	Phister, 1979
$MM = 1.0\ KDSI^{1.40}$	Jones, 1977
$MM = 0.70\ KDSI^{1.50}$	Halstead, 1977
$MM = 28\ KDSI^{1.83}$	Schneider, 1978

MM = Man Months
KDSI = Thousands of delivered source instructions.

An example of the construction of a parametric model

The table below shows the costs and technical characteristics of steam jet ejectors, which is a type of pump without any moving parts.

Number	1	2	3	4
Cost (£)	300	700	410	600
Capacity (kg dry air/hr)	32	109	181	227
Suction Pressure (Pa)	20000	13332	40000	26664
Steam Consumption (kg/kg air)	3.4	6.2	1.2	2.1

A number of possible models were considered, for example linear, log-log and log-linear but the following was considered to be the best fit.

A Cost Estimating Relationship (CER) of the form

$$\text{Log } C = a + b\text{Log}Q + d\text{Log}P + e\ \text{Log}S$$

where C = Cost; Q = Ejector Capacity; P = Pressure;
S = Steam Consumption
is applied to the data; giving;

$$\text{Log } C = 3.844346 + 0.460846\text{Log } Q - 0.49535\text{Log } P + 0.136116\text{Log } S$$

$$\text{Log } C = 3.844346 + 0.460846 \text{Log } Q - 0.49535 \text{Log } P + 0.136116 \text{Log } S$$

This formula is the Cost Estimating Relationship (CER) for the product and is a **mathematical model** which represents the relationship between the cost and the important parameters (or cost drivers) for this particular product (the steam jet ejectors).

A test of the model against known data for other steam jet ejectors.

Log C = 3.844346 + 0.460846Log Q - 0.49535Log P + 0.136116Log S

(C = Cost, Q = Ejector Capacity, P = Pressure, S = Steam Consumption

There is data for the known cost of three more items (numbers 5,6, and 7) against which the model can be tested.

Number	5	6	7
Capacity (Q)	109	181	73
Suction Pressure (P)	13,332	20,000	333,000
Steam Consumption (S)	6.2	3.4	1.6
Actual Cost (£) (known)	700	670	300
Calculated Cost (£) (C)	699	666	307
Error %	0.08%	0.64%	2.37%

Further Problems of Parametric estimates

A cost estimating model is an adequate relationship - it is an approximation to the true underlying relationship.

The previous example derives a CER from 4 sets of data with four unknown parameters of the CER and therefore could have been solved using simultaneous equations.

When there are more sets of data than unknown parameters then regression methods are used.
(Ref: Stanford Weisberg, Applied Linear Regression, Wiley, 1980).

Therefore parametric cost (or time) estimating methods are prone to the same sorts of problems as econometric problems.

Least squares regression model makes a number of assumptions which are violated when:

- relevant variables (cost drivers in this case) are omitted.
- irrelevant variables are included.
- the relationships between the cost and the cost drivers are not linear
- the parameters of the underlying variables are not constant over time
- errors in the data.
- correlation between two or more variables.
- the number of observations is less than the number of independent variables - a lack of data.

Parametric models can generally be classified as commercial or company developed.

Commercial computer packages are available for this purpose

Complex parametric models may consist of many interrelated Cost Estimating Relationships (CERs), as well as other equations, ground rules, rules of thumb, assumptions, and variables that describe and define the situation being studied.

An alternative to deriving C.E.R's from raw data is to use a "ready-made" formula, which are sometimes published by their originators or are sold as part of computerised cost estimating packages.

- These are mainly top down methods

e.g. Martin Marietta's PRICE systems.

FAST, GRUMMAN, ONCOST AND ETA

very expensive !!

Summary of some cost estimating methods.

Model Category	Description	Advantages	Limitations
Analogy	Compare project with past similar projects	Estimates are based on actual experience	Truly similar projects must exist
Expert Judgment	Consult with one or more experts	Little or no historical data is needed; good for new or unique projects	Experts tend to be biased; knowledge level is sometimes questionable
Bottom-Up	Individuals assess each component and then component estimates are summed to calculate the total estimate	Accurate estimates are possible because of detailed basis of estimate; promotes individual responsibility	Methods are time-consuming; detailed data may not be available, especially early in a program; integration costs are sometimes disregarded
Parametric Models	Perform overall estimate using design parameters and mathematical algorithms	Models are usually fast and easy to use, and useful early in a program; they are also objective and repeatable	Models can be inaccurate if not properly calibrated and validated; it is possible that historical data used for calibration may not be relevant to new programmes.