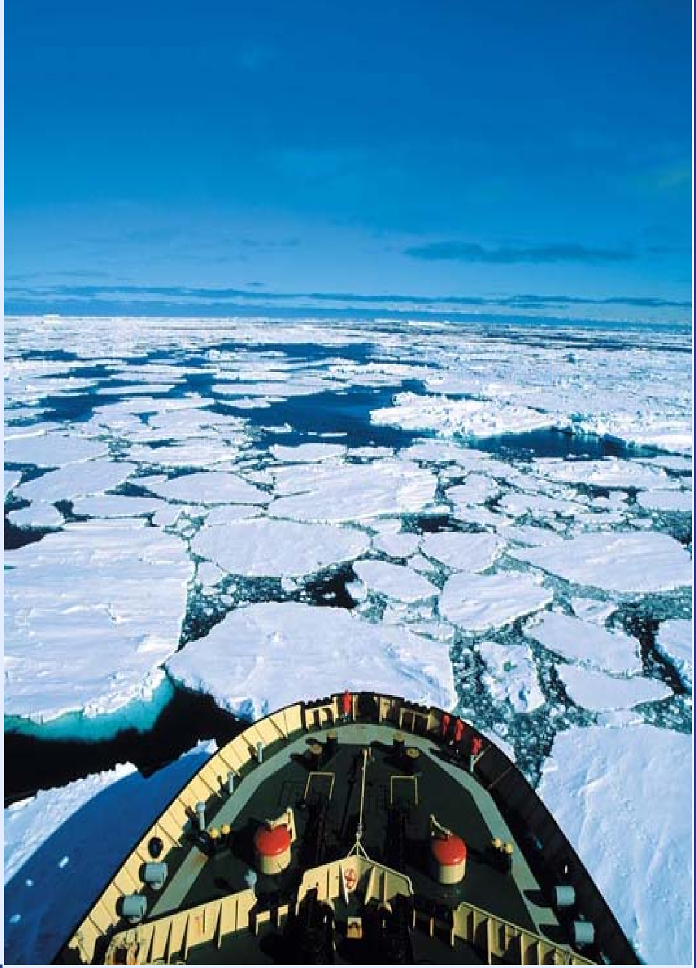


TSLRIC Conference

Wellington

16 – 17 July 2003

PRICEWATERHOUSECOOPERS

Agenda

1. The economics of access pricing
2. Definition of increment
3. Forward looking costs
4. Incremental cost models
5. Recovery of fixed common and joint costs

Regulatory objectives

- In general a regulator will seek to achieve an outcome that mimics the operation of an efficient market.
  - **Allocative efficiency** – prices should reflect society's costs of production to ensure that scarce resources are allocated to their most valuable use.   This implies that the marginal cost (price) to consumers should equal the marginal cost of production.
  - **Productive efficiency** – a given production should be produced at the lowest possible cost, i.e. efficient entry is encouraged and inefficient entry is deterred.
  - **Dynamic efficiency** – efficient investments should be encouraged together with the expansion of choice and innovation. This requires that an investor has a rational expectation of being able to cover the total opportunity costs of an investment.
- A regulator may also be mandated to meet certain public policy objectives (which might not be satisfied by a competitive market)
  - Universal service
  - Non-discrimination
- There is likely to be some tension between these objective. As a result the regulator is faced with task of finding the right balance between its objectives

The rise of incremental cost based prices for interconnection

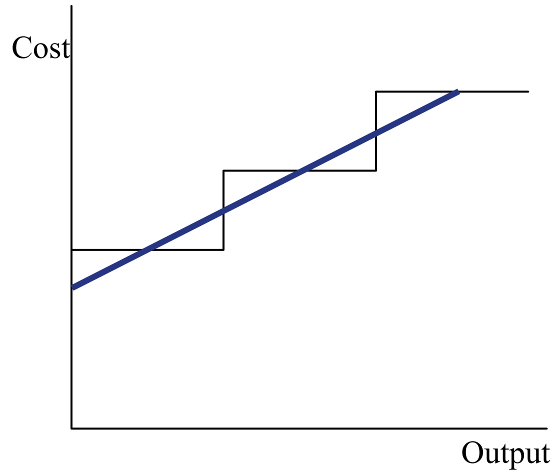
- In recent years long run incremental costing has become the dominant methodology for setting regulated interconnection charges in telecommunications markets around the world
- Some countries where LRIC has been or is being implemented:

UK	USA	France	Netherlands
Australia	Germany	Belgium	Greece
Hungary	Hong Kong	Brazil	Mexico
Ireland	Spain	Switzerland	Austria
Sweden	Denmark	South Korea	Romania
South Africa	Italy	Peru	Portugal

- In all cases the form of LRIC is defined in Total Service or Total Element element terms. In all cases a mark-up to contribute to fixed common and joint costs added.
- So why has the use of LRIC become so pervasive?

The rationale for incremental cost based prices

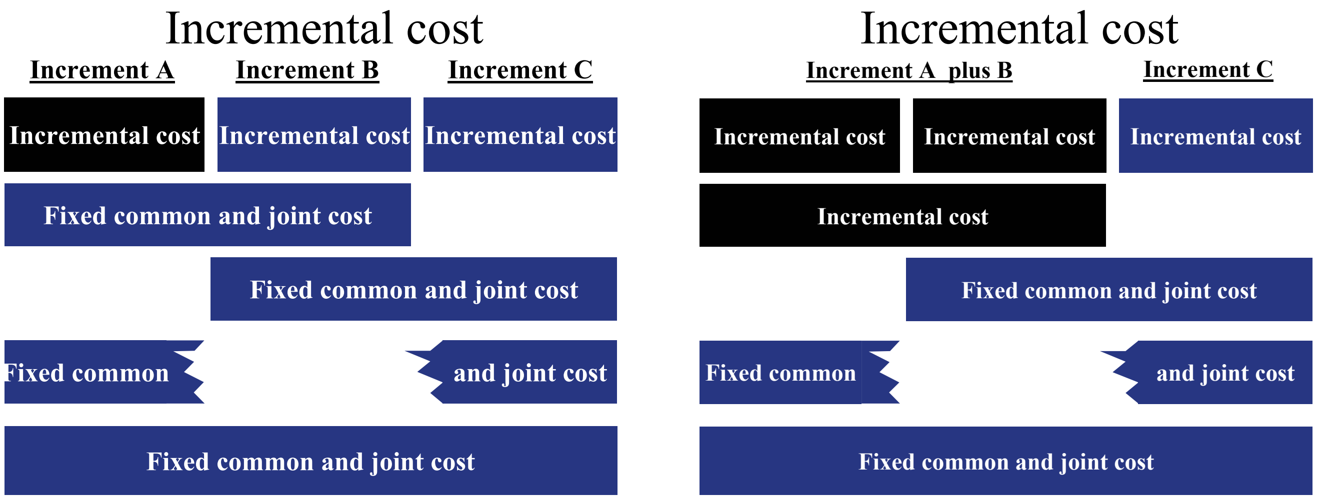
- The answer lies in its ability to address regulatory objectives.
- Economic theory tells us that **allocative efficiency** is maximised where products are priced at their marginal cost.
- In industries, such as telecoms, where capital investment tend to significant, and lumpy due to the modularity of equipment, marginal cost is highly volatile with obvious problems for setting prices.
- A long run incremental cost measure has been adopted to ameliorate this problem:
  - Moving to the long run captures capital costs
  - Expanding the increment of output from one additional unit deals with the equipment modularity problem
- Incremental costs are naturally a forward looking measure and therefore exclude **productive inefficiencies** associated with embedded historical cost measures.



- Which leaves the question of **dynamic efficiency**. If economies of scale or scope are present setting prices equal to LRIC will not provide the necessary investment incentives and is ultimately unviable. LRIC based prices therefore are set to include a contribution to fixed common and joint costs enabling budget balance.

Implications of the increment definition

- A first question in building an incremental cost model is what increments of output should be evaluated.
- The answer to this question fundamentally depends on the application to which the cost estimates are to be put. It is intrinsically linked the question of how fixed common and joint costs are to be recovered. And may be constrained by practical concerns.
- First, it is useful to consider what the general implications of different increments are.

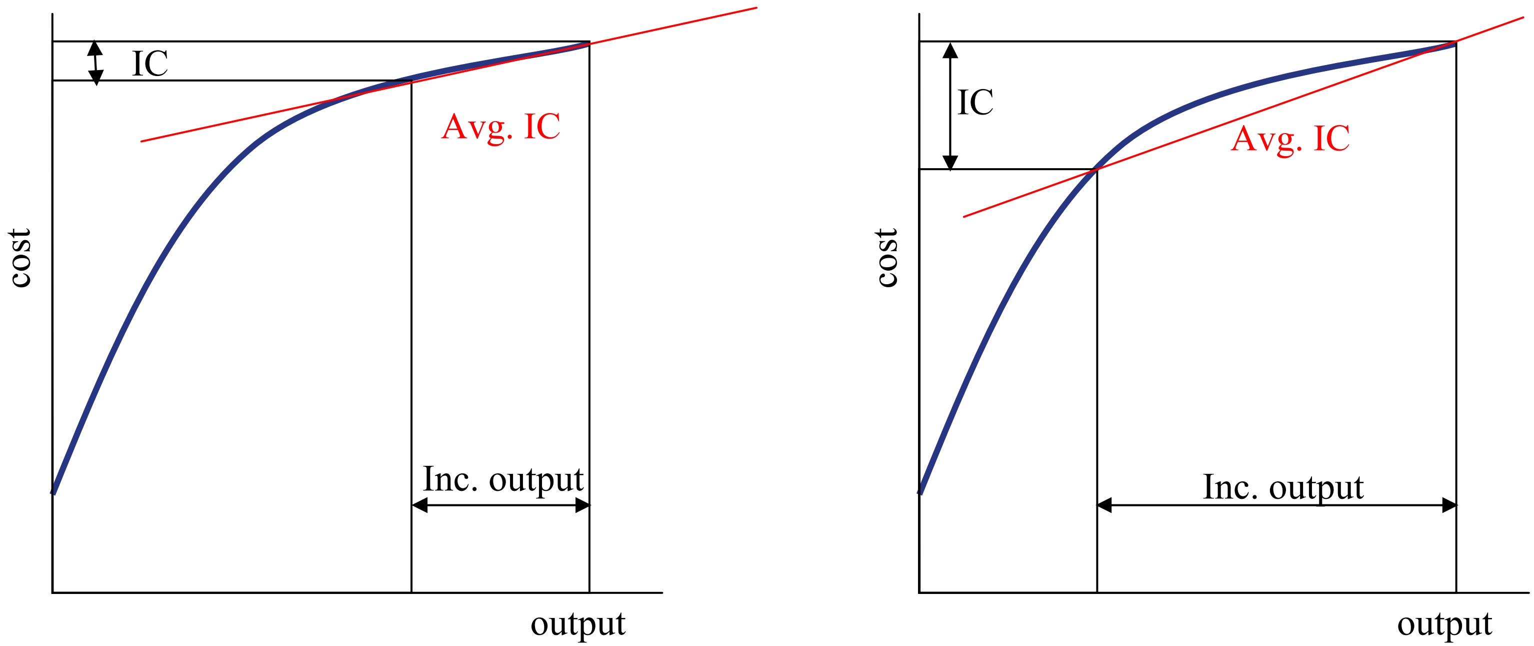


- In general if marginal costs are falling with volume or if there are a range of common costs which do not span the entire output of the firm then a narrow incremental cost definition results in lower average incremental costs and more common costs to be recovered through a mark-up.

2. Definition of increment

Implications of the increment definition (2)

- Second, if marginal costs fall with output the average incremental cost of smaller services will be less than the average incremental costs of larger increments even if services are functionally the same.



- The use of narrow increment definitions may be inconsistent with regulatory objectives for equity and non-discrimination.
- Implies that the cost and price of the same functional network component or services is different depending on the service it supports.

Implications of increment definition (3)

- If the goal is allocative efficiency then the increment should be defined as the service for which prices are to be set.   So, if for example, if prices are to be set for local PSTN call termination it is natural that this service is defined as the increment.
- **However**, economic efficiency can only be achieved if fixed common and joint costs are recovered over services in accordance with Ramsey principles (inverse elasticity rule). Note in this case common costs will be larger due to the narrow increment definition.
- If fixed common and joint costs are not going to be recovered according to Ramsey principles the value of using a narrow service increment is completely negated.

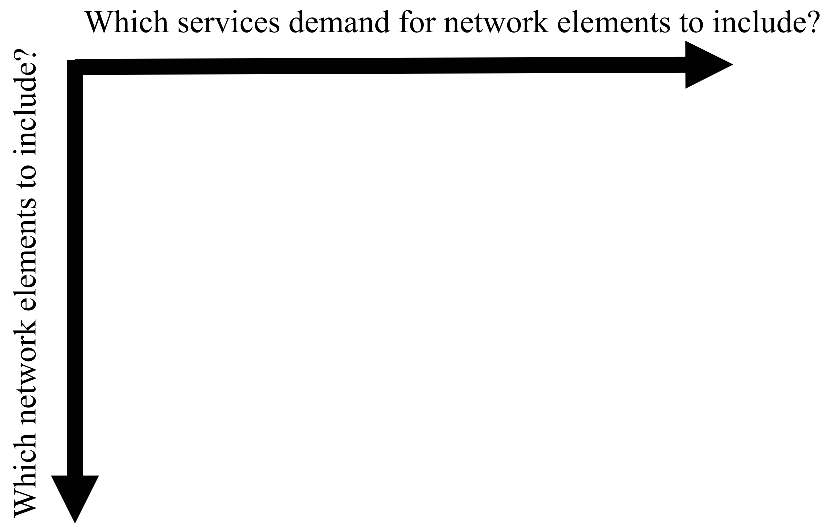
2. Definition of increment

Elements of increment definition

- There are two dimensions to defining the increment:

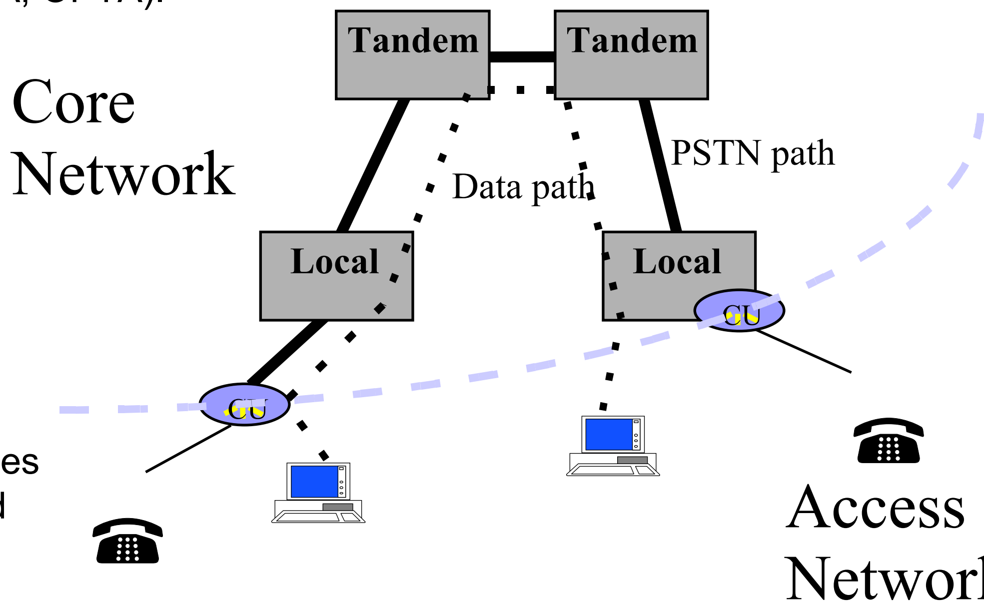
- Which network elements
  - network elements used to provide interconnection services
  - Other network elements giving rise to economies of scope

- Which services
  - Interconnection services
  - Other services using those network elements giving rise to economies of scale



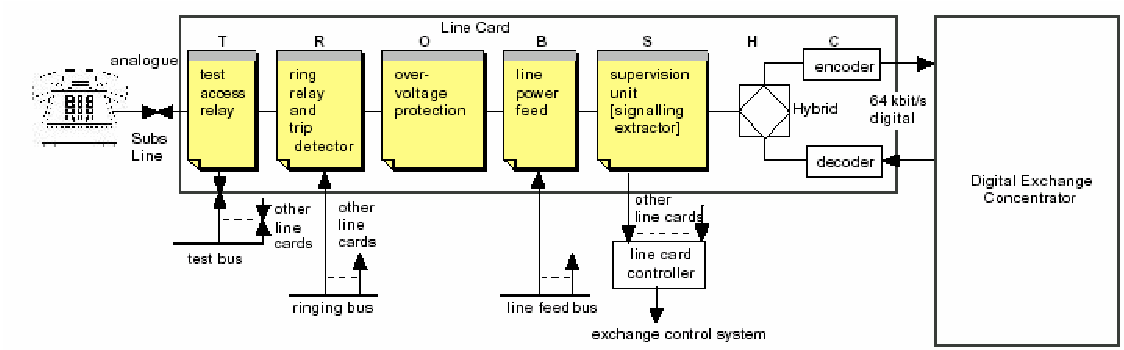
TSLRIC increment definition

- Divides network into Access and Core
- Boundary for PSTN network is point at which capacity is contended.
- Boundary for data services is typically at the same physical point where PSTN boundary is located.
- Demand for all services (Total Service) using access and core networks is usually included (Oftel, ComReg, ACCC, NTA, OPTA).
- Costs of equipment and activities which are entirely incremental to a service for which a regulated price is not required can be ignored.
- The TSLRIC of each increment is then distributed to network components
- The distributed incremental cost by network components therefore includes inter-component intra-increment fixed common and joint costs



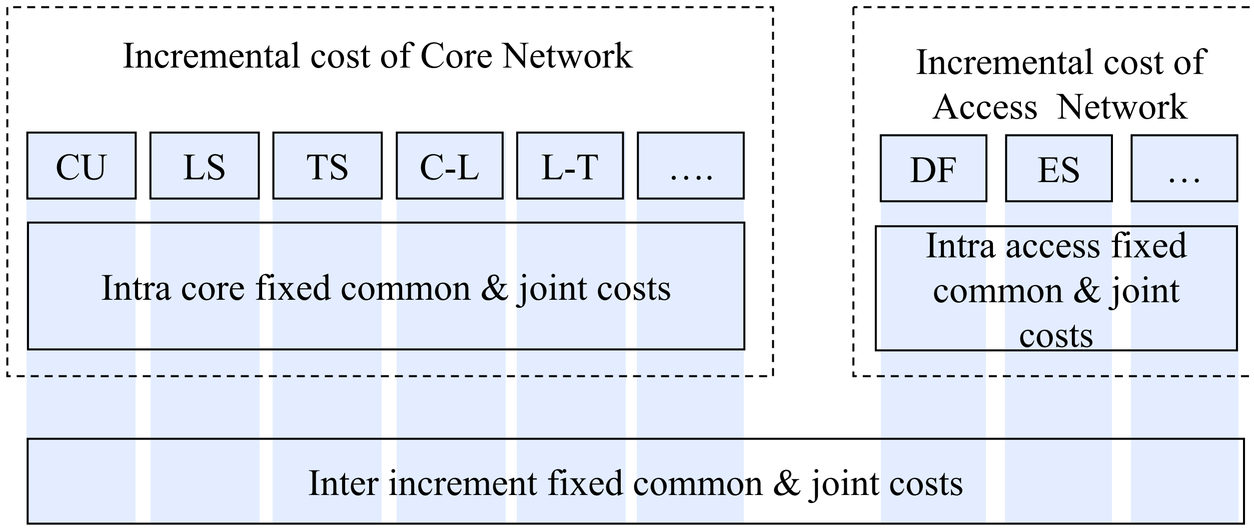
Core Access boundary

- The line interface card is the point where the copper pair is joined to the Core network
- The number of line cards is a direct function of the number of connected subscriber lines which has led some regulators to treat line cards as incremental to the access network
- However the card performs a range of functions in addition to terminating the copper pair on the network:
  - **B**attery feed, **O**ver-voltage protection, **R**inging current, **S**upervision, **C**oding, **H**ybrid transformer, and **T**esting – BORSCHT
- B, R H and C, which account for the bulk of the cost, are only used when calls are made



- Oftel recognised that the number of line cards was correlated with the number of subscribers but that much of the function of a line card was engineered to meet call demand. Vendors combined the lines and calls function in the line card because they were selling to integrated operators (providing lines and calls). Oftel concluded if the access and core networks were truly separable the calls and lines functions of line cards would be provided separately. Oftel therefore split the calling from the lines functions of the line card to allocate costs to the Core network.

Illustrative model outputs under TSLRIC



Increment definition: conclusions

- Narrow service based increment definitions should **not** be adopted unless:
  - Ramsey prices are to be set
  - Differential pricing for the same functional network service is contemplated
    - e.g. a different price for a local switch minute depending on the service using the local switch

- Otherwise, a Total Service definition should be adopted which:
  - Includes all network elements used by the regulated interconnection services
  - Includes other network elements giving rise to economies of scope
  - Includes all service demands on those network elements

- This definition is consistent with international practice

Forward looking costs

- Incremental cost is naturally an economic concept and it is natural to measure costs on a forward looking basis – as opposed to a historical or accounting basis.
  - Measure of economic as opposed to accounting cost
  - Excludes embedded historical inefficiencies
  - Provide better build or buy signals
  - Disciplines price in competitive mark
- Forward looking cost can be defined as the cost that would be incurred today of replacing existing equipment's functionality and capacity.
- Forward looking cost may differ from historical cost for a variety of reasons:
  - General inflation
  - Specific real inflation
  - Historic costs may have been incurred for reasons which are no longer relevant
  - Technologies which may have been deployed in the past may have been superseded

Estimating forward looking costs

- The main stages in estimating forward looking costs are:
    - What type of equipment should be used to replace existing equipment?
    - How much equipment is needed?
    - What is the gross investment in that equipment?
    - What is the annualised cost of that investment?

What type of equipment should be used to replace existing equipment?

- There have been and continue to be significant developments in telecommunications technology. The estimation of forward looking costs requires a judgement about what are the Modern Equivalent Assets (MEA) which should form the basis of estimates of forward looking costs.
- The MEA standard which should be used is that which would condition the value of investments of a national operator in an effectively competitive market. It should reflect the investment choices and constraints faced by an efficient operator
  - It is not the latest “bleeding edge” technology
  - Rather it is the “best in use” technology
  - The CCA handbook (Prof Ian Byatt) recommends defining MEA in terms of those technologies which the operator plans to implement in the medium term
- MEAs
  - Transmission – optical fibre, SDH and WDM
  - Switching – latest technology circuit switches / packet switches?
  - Access – copper / fibre copper hybrid

How much equipment is needed?

- The quantity of MEA equipment that an efficient operator would require to satisfy anticipated demand (current plus forecast growth).
- The quantity of equipment critically depends on:
  - The network topology; and
  - The achievable equipment utilisations
- Both should be set according at realistic levels for a real world efficient operator.
  - No real world operator can efficiently re-cast its network topology in one pass . Rather the efficient course of action is to incrementally redesign the network to exploit technological and other changes when economically viable. Scorched node not scorched earth
  - Equipment utilisation levels should be those achievable by an efficient operator not the theoretical factory specifications allowing for:
    - Grade of service;
    - Resilience;
    - Distribution of traffic;
    - Growth; and
    - Uncertainty

What is the gross investment?

- The cost that would be incurred today to bring the equipment into service
  - Today's price
  - Includes planning, supervision, installation and testing costs as well as pure basic equipment cost
  - Includes the opportunity cost of capital tied up during installation and commissioning period
    - Either by including capital work in progress in asset base, or
    - By addition of capitalised interest to the investment cost. This can be achieved by the following formula

$$I'_{t=0} = I_{t=0}.(1+i)^{-u}.(1+r)^{u} = I_{t=0}\left(\frac{1+r}{1+i}\right)^{u}$$

    - Inputs are cost of capital *r*, time to commission *u*, asset inflation *i*

What is the annualised cost of investment?

- Forward looking gross investment must be converted into an annual capital cost comprising economic depreciation and the cost of capital
- LRIC models include estimates of economic depreciation
- Economic depreciation is the change in value of an asset from one period to the next
  - The change in NPV of future cash flows
  - Revenues constrained to earn cost of capital
- Main drivers of cashflow are:
  - Change in asset price over time driving change in output price
  - Utilisation profile of asset
  - Operating cost profile of asset
- If cashflows are front ended the depreciation profile should also be front loaded. Conversely if the cashflows are back ended then so should the depreciation profile.
- Cashflows can be modelled explicitly – informationally difficult - or
- be approximated by another method, e.g. a growing annuity or tilted straight line depreciation

Approximations of economic depreciation

- The complexities of modelling all cash-flows over an extended period has meant that most models of depreciation have followed either a growing annuity approach in the general form:

$$C_t = I_{t=0} \cdot \frac{(r-i)}{1-\left(\frac{1+i}{1+r}\right)^n} . (1+i)^{t-1}$$

  - Inputs are cost of capital *r*, useful economic life *n*, rate of change in value of the asset *i*
  - Assets subject to a higher degree of technological obsolescence will tend to have shorter economic lives and faster negative changes in value of the asset
  - Many models wrongly interpret *i* as simply being the rate of asset specific inflation
- Or tilted straight line depreciation in the form:

$$C = I\left(\frac{1}{n} + r + i\right)$$

- Other models of depreciation which do not allow for the rate of change of asset value, including simple annuities, have also been applied but are completely inappropriate in the majority of cases

Forward looking costs: conclusions

- “Best in use” rather than absolute latest technology
- Planned use by a national operator

- Scorched node not scorched earth
- Achievable levels of utilisations reflecting actual environment

- Capture all costs of bringing asset into service including opportunity cost of capital

- Depreciation schedule must reflect change in economic value of asset

Modelling approaches

- There are essentially two approaches to modelling incremental costs:
  - **Top-down** - analysis of how incurred cost (based on re-valued management accounting and operational information) varies with respect to changes in volume
  - **Bottom-up** - engineering construction of the quantities and cost of equipment required to produce a given level of output

	Top Down	*Bottom Up*
Positives	Based on actual (re-valued) costs Reconcilable Reflects real complexity/uncertainty	Fewer confidentiality issues Perfect efficiency Transparency
Negatives	More confidentiality issues May include inefficiencies	May underestimate and/or omit costs Poor modelling of opex Danger of over optimisation

- Either modelling approach, properly executed, is in principle capable of producing reasonable estimates of incremental costs but this requires considerable care.

The primary goal of a model must be accuracy

- While both modelling approaches are capable of producing accurate estimates of incremental costs it is important to recognise the innate tendencies of each.
- A top-down model is better able to reflect the real costs of operation since it is an observation of the real world. However, it is possible that the observed costs of an operator may include a level of inefficiency which the regulator may wish to exclude for the purpose of setting interconnection prices. Since inefficiencies are asymmetric there is a natural tendency for top-down models to overstate rather than understate costs.
- By contrast bottom-up models have a tendency to underestimate costs. Bottom-up models may omit relevant costs because their significance has not been recognised in the model construction. They may also impose “ideal” levels of efficiency which are not achievable in reality.
- It is very unwise to rely on a bottom-up approach in isolation. Even where there is a preference for bottom-up modelling one would be well advised to validate its results with a top-down exercise.

In the USA bottom-up models have been used extensively for many years and have undergone long periods of development, testing and refinement. However the cost estimates of network elements for the two most widely used models differ by approximately 50%. For example one model estimates the average monthly cost of local loop at $23 while another yields an estimate of $16. For the US as a whole this represents a discrepancy of nearly $17 billion per year.

4. Incremental cost models

Bottom up models usually hypothesise the complete rebuilding of the network

- Most bottom up models calculate a point estimate of cost for a given level of demand and assume that the network is built in one pass (albeit often constrained by scorched node assumption)
- This is an extreme abstraction from reality
  - real operators construct its network incrementally
  - A real operator takes advantage of the latest technological but deploys them in light of its existing network. To do otherwise would be inefficient.
  - No operator can or should continuously replaces its network to constantly employ the most recent, least-cost technology.
  - Alfred Kahn states:
    - “Firms would incur the heavy sunk costs of investing in totally new facilities, embodying the most recent technology from the ground up, only if prevailing market prices were high enough to provide rapid depreciation of those costs and rates of return that Jerry Hausman has estimated would have to be two or three times current costs of capital. “
- The use of a scorched node assumption goes some way towards moderating this effect

Other issues arising in bottom up modelling

- The process of constructing a bottom-up model will typically involve the regulator working with all operators in the jurisdiction to agree the model methodology and collect input parameters and assumptions from all parties.
- Only the incumbent operator typically has experience or data of operating a ubiquitous national network. Other operators will tend to have smaller networks focused on particular customer segments
  - Other operators tend observe higher equipment utilisations because they tend to serve higher volume customer segments in narrower geographies. The incumbent operator services all segments and geographies and will tend to have lower equipment utilisations. Such differences need not be the result of different levels of efficiency
  - The incumbent operator may operate to different grade of service. While a higher grade of service will always lead to higher costs one cannot conclude that these costs are inefficiently incurred.
  - The smaller networks operated by alternative operators means they are less likely to experience the same level of costs of transition, e.g. of technology replacement.
- The expectations of what are reasonable levels of utilisation and cost differ because of the different experiences of different operators. It is important to remember that it is a national operator which is being modelled.

4. Incremental cost models

Bottom-up models tend to neglect operating costs and indirect capital investments

- Bottom-up models typically contain explicit algorithms to define the quantity of direct capital equipment.   However, they often do not model operating costs effectively.
- Most bottom-up models apply simple percentage multipliers to incorporate operating costs and indirect investments. Typically in the form:
  - Indirect investment = a x direct investment
  - Direct operating costs = b x investment
  - Indirect operating cost = c x direct operating cost
- There is no reason to believe that such relationships hold true. At best they may yield the correct result in a specific set of circumstances but if those circumstances change it is unlikely that the same coefficients would still hold true.
- The coefficients are often based on simple benchmark analysis, e.g. Oftel, ACCC which may not be applicable to a particular jurisdiction for a variety of reasons:
  - Accounting capitalisation policies
  - Environmental differences
  - Variation in input prices
  - Taxes
  - Exchange rate effects, etc

Capturing any inefficiencies in top-down models

- Top down models require the revaluation of investments on a forward looking basis. This should eliminate capital inefficiencies associated with the embedded historical costs.
- However, there may be a concern that either these are not fully captured or that operating cost inefficiencies may remain.
- It is therefore common practice for regulators to undertake comparative efficiency studies of operators to identify any level of inefficiency.
- A variety of mathematical and statistical techniques are used for this purpose, e.g.
  - Simple ratio analysis
  - Data envelopment analysis
  - Stochastic frontier analysis
- More sophisticated studies can take account of different operating conditions and environmental factors
- The use of such comparative studies and the inclusion of adjustments indicated by them provides comfort that top-down models do not include the cost of inefficiency

Incremental cost models: conclusions

- Bottom-up models should not be used in isolation. They have an inherent tendency to underestimate real world costs and must be calibrated with top-down information
- The use of top-down models provides comfort that cost estimates are realistic. Comparative studies provide evidence of an incumbents level of efficiency
- Best practice points to the development of both top-down and bottom-up models together with a reconciliation of the two approaches.
  - UK
  - Netherlands
  - Ireland
  - France
  - Switzerland
  - Sweden
  - Denmark

Which costs are not attributable in an incremental cost model

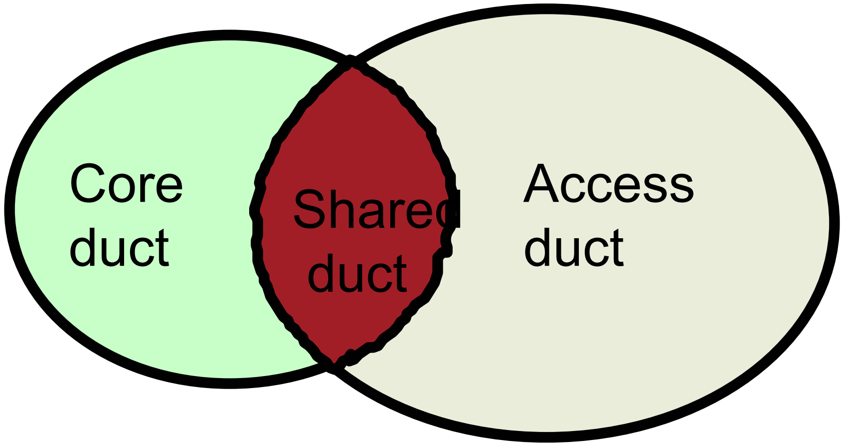
- Only two categories of costs can not be attributed and therefore must be recovered by separate mark-up:
  - Fixed common costs – costs that are independent of output but which are a required input for more than one increment of output
  - Joint costs – costs which are dependent on the output of more than one increment but which can not be assigned to produce more of one increment at the expense of another

	Specific to increment	Common across increments
Directly variable	✓	✓
Indirectly variable	✓	✓
Variable but in fixed proportions	✓	✗
Fixed	✓	✗

✓ Incremental ✗ not incremental

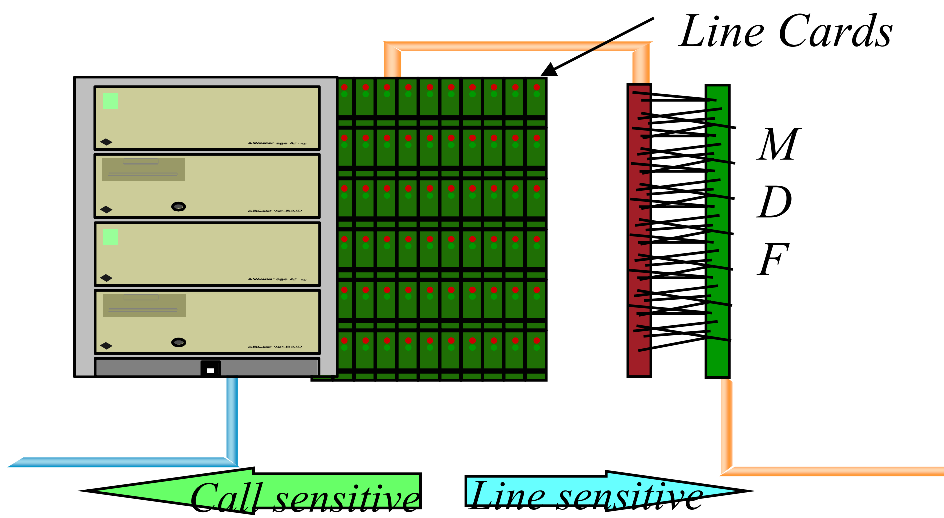
- **Just because a cost is common does not mean it cannot be incremental**

Main sources of fixed common and joint costs



Duct and trench shared by access and core cables

Equipment at concentrators which provides both lines and traffic functions



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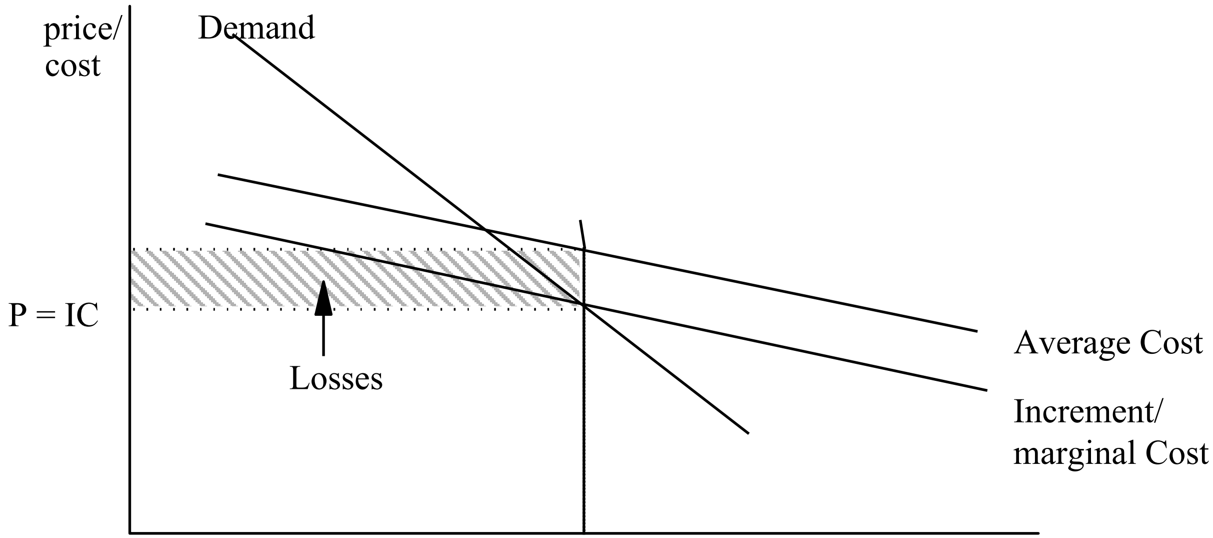
Recovery of fixed common costs

- In presence of fixed common and joint costs setting prices at incremental costs will not allow a firm to cover its total costs
- A mark-up is therefore required to cover fixed common and joint costs



- The Telecoms Act recognises this and provides for the recovery of “a reasonable allocation of forward looking common costs”
- There is no causal basis for recovering fixed common and joint costs. In this respect all mark-up methods are arbitrary.

“a reasonable allocation…”

- There is no causal basis for recovering fixed common and joint costs.   In this respect all mark-up methods are arbitrary.

- What does a reasonable allocation mean? Some suggestions:
  - In total allows the operator to recover all its forward looking fixed common and joint costs
  - The allocation is not biased in favour of a product of group of products, or an operator or group of operators
  - Allocation only to increments which require the fixed common or joint costs as an input.
  - The method of recovery is transparent
  - Result in a price between incremental and stand alone cost

5. Recovery of fixed common and joint costs

Recovery methods

- **Ramsey pricing** is designed to minimise consumption distortions– mark-up inversely proportional to super elasticities
  - Requires estimates of market own price and cross elasticities.
  - No examples of regulators explicitly calculating Ramsey prices but widespread application through price caps
  - Results in different interconnection prices depending on final product
- **ECPR** sets access prices equal to the marginal cost of access plus the opportunity cost of by-pass
  - Converges with Ramsey outcome when final prices are efficient
  - May reduce dynamic and productive efficiency incentives
  - Results in different interconnection prices depending on final product
- **Equi-Proportional Mark-up** – mark-up in proportion to incremental costs
  - Essentially fully allocated cost
- **According to some related metric** – e.g. allocate duct costs on number of cables
  - No single method
- **Equal shares** – splits fixed common costs equally between increments.
  - Negotiated Shapley outcome (Prof LS Shapley)

Recovery methods: conclusions

- Prices must allow for a full recovery of forward looking fixed common costs
- Of the range of methods available only Ramsey and ECPR seek to satisfy any economic efficiency goals. ECPR is specifically disallowed by the Telecoms Act. The direct estimation of Ramsey prices is difficult to apply in practice.
- EPMU and metric based allocations only have their simplicity to recommend them
- The equal shares method seeks to replicate the outcome of two rational parties negotiating how to share the costs of a shared input where absent a negotiated settlement they would each have to bear the full costs of the input.
- Notwithstanding practical issues first best option is Ramsey, second best is equal shares.