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HOMEWORK 5

1

Following the equations given on the slides, here follows the steps and results regarding the costs in Millions of Euros.

The learning model is based on the following two equations:

$$C_{CA} = C_{TFU} N^{-b}$$

$$r = 2^{-b}$$

Where r is the learning factor, b = 0.14 is the learning coefficient, N is the number of units, C_{CA} is the cumulative average cost and C_{TFU} = 5M€ is the theoretical cost of the first unit. The learning factor is r = 90.75%.

N = 1: with a single unit, total cost, average cost, and cost per unit coincide.

N = 2: C_{CA} = 5M €·$2^{-0.14}$ = 4.537M €

Total cost is: C_{tot_N}=N·C_{CA} = 2·4.537M € = 9.075M €

The cost per unit is: C/U = C_{tot_N}- $C_{tot_{N\text{-}1}}$= 9.075M€–5M€ =4.075M€

N = 3: C_{CA} = 5M €·$3^{-0.14}$ = 4.287M €

Total cost is: C_{tot_N} = N·C_{CA} = 3·4.287M € = 12.861M €

The cost per unit is: C/U = C_{tot_N}- $C_{tot_{N\text{-}1}}$= 12.861M€–9.075M€ = 3.786M€

N = 4: C_{CA} =5M €·$4^{-0.14}$ =4.118M €

Total cost is: C_{tot_N} = N·C_{CA} = 4·4.118M € = 16.472M €

The cost per unit is: C/U = C_{tot_N}- $C_{tot_{N\text{-}1}}$ = 16.472M€–12.861M€ = 3.611M€

To confirm the accuracy of the calculations, we can notice that every 2N units the cumulative average cost decreases by a percentage equal to r. In fact:

90.75% $C_{CA_{N=1}}$=4.538M€≈$C_{CA_{N=2}}$

90.75% $C_{CA_{N=2}}$=4.118M€≈$C_{CA_{N=4}}$

UNIT NUMBER	COST PER UNIT	CUMULATIVE AVERAGE COST	TOTAL COST
1	5.000	5.000	5.000
2	4.075	4.537	9.075
3	3.786	4.287	12.861
4	3.611	4.118	16.472

	Analogy-based	Parametric	Bottom-up
Primary phase of application	Mostly used before committing to a specific design choice; used to compare existing solutions.	The model requires thorough data gathering and adjustments, therefore it is mostly used at preliminary phases.	Mostly used in later stages such as production since it is not able to adapt to different design choices ("new estimates must be created for each alternative scenario").
Reliability in prediction	Accurate for minor differences from the analog under analysis; good for very similar design, quickly loses reliability.	No need for empirical factors thanks to actual observations; loses predictive ability far from the relevant data range according to statistics.	Not based on statistical analysis and therefore cannot guarantee "statistical levels of confidence"
Analysis time	Quick to implement once found the best analog for the project.	Gathering data ad fitting the parameters is time consuming.	Creating such a model needs major work in terms of cost and time.
Reliance on existing data and external factors	Heavy reliance on historical data (sometimes can be hard to find the best fit for a specific project); depends on empirical "adjusting factors"	Heavy reliance on both historical data and mathematical models (already existing or to be implemented).	Relationships between different contributing factors are chosen by experts.

Reasoning: the above criteria were chosen to complement each other because they collectively cover the essential aspects of cost modelling without being specific to any one model.

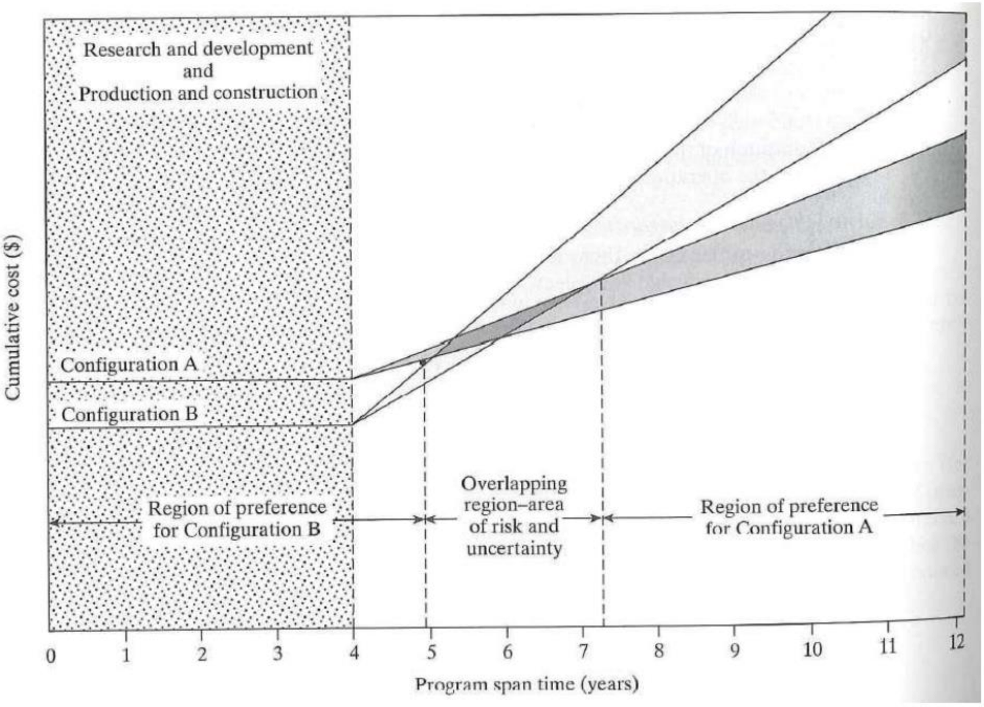
Primary *phase of application* addresses when the model is most useful in a project lifecycle. It takes into account the practical timing for deploying a model based on the availability of project details. However, it does not measure how reliable the predictions are or how long it will take to implement, which is why it needs to be considered together with *Reliability in Prediction* and *Analysis Time*.

Reliability in prediction takes into account the trustworthiness of the model's output, which is crucial for decision-making but does not determine when or how quickly a model can be applied. For instance, a reliable model might be time-consuming or dependent on vast amounts of data. Which means, it needs to be balanced with other criteria like *Analysis Time* and *Reliance on Existing Data* to avoid over-reliance on one factor.

Analysis time measures the efficiency of the model in terms of how quickly results can be generated. It addresses practical concerns like deadlines and resource availability. Fast models may sacrifice accuracy or reliability, so *Analysis Time* alone cannot determine a model's overall suitability. It needs to be evaluated with *Reliability in Prediction* to ensure speed does not compromise quality, and with *Reliance on Existing Data* to see if speed is achievable without extensive data gathering.

Reliance on existing data and external factors assesses how reliant the model is on historical or prior project data to make predictions and the model's sensitivity to external changes, for example market conditions, technological advances, or regulatory shifts. While external factors focus on adaptability to unforeseen changes, they do not account for how quickly or accurately the model can respond.

3



To reduce the identified risk, I would first comprehend the results from the sensitivity analysis and start building a plan from that.

General techniques might include identifying the variables or assumptions that impact most heavily on the reliability of the break-even analysis and therefore on the size of the overlapping area in the graph.
In order to reduce the area of uncertainty of the single configuration we could investigate which factor influence each of the two options separately; it might result that they depend on the same or different economic and production processes, our research should take this into account. It is important to note that uncertainty can come from accuracy of break-even analysis or of the very input data that is used.

From the economic side it might be useful to carry market research: trends and competitors can heavily influence our estimates. Another economic factor might be the regulations and how they evolve, they must be monitored constantly in order to avoid expensive late changes.
From the process side it is necessary to understand the level of technology and its readiness, which might result in more expensive procedures or costs for example to train personnel or buy new machines.
This analysis should be carried by experts in the specific field we are working in since many of the decisions require experience and empiric reasoning.

Much of this work should be carried out in the first phases of the project, namely during research and development but shouldn't be disregarded during the later stages since the market is constantly evolving and it is impossible to draw conclusions with accuracy.