Proceedings of the 7th International Conference on Economic Management and Green Development
DOI: 10.54254/2754-1169/27/20231251

Assessment of the Construction Project Costs by Using the Learning Curve

Hao Wu[1,a,*]

[1]*Southeast University Cheng Xian College, No.6, Dongda Road, Jiangbei New District, Nanjing City, Jiangsu Province*
a. 3220108939@qq.com
**corresponding author*

Abstract: The project feasibility study, which is the scientific technique, a thorough technical and economic analysis, and a demonstration of the project's construction before the project decision are the most crucial components of the project's preparatory work. This paper uses the one-factor learning curve to analyze the project cost and then obtains the feasibility study results for the project. The Wright models are the foundation of the tool developed. The model was chosen due to its applicability to the construction sector and its effectiveness in terms of fitness (ability to fit historical data) and predictability in the past (ability to estimate future data).

Keywords: project feasibility, project evaluation, learning curve, engineering economy

1. Introduction

Project price management is crucial for both the owner and the contractor. Construction and investment management should follow investment law and science and carry out market research, investment decision-making, and investment management. The project feasibility study is the most important content in the preliminary work of the project, which is the scientific method and working stage of the comprehensive technical and economic analysis and demonstration of the project construction project before the project decision. The feasibility study of construction projects is also called the "feasibility programme study." The United States was the first country to adopt the feasibility study, while China started the study relatively late. At present, the feasibility study has been widely paid attention to in China and has achieved certain results. In the face of an engineering project, we need to use the relevant learning curve of engineering economics to analyze the economic evaluation effect, generally analyze the qualitative analysis of economic evaluation profitability, evaluate the economic evaluation foreign exchange effect, evaluate the project economy evaluation, and finally evaluate whether the project is feasible. Feasibility studies of investment projects generally include an investment opportunity study, a preliminary feasibility study, and a detailed feasibility study. This paper is an elaboration of a detailed feasibility study of the project.

2. Literature Review

Wright establishes the learning curve, and the learning curve is applied to various fields. In Arrow and Dutton, Thomas used a uni-variate learning curve to measure the learning rate learned from

DOI: 10.54254/2754-1169/27/20231251

experience [1-2]. Later, after the improvements made by some scholars, the two-factor learning curve model was established and applied to the learning effects of different industries and technologies.

The first application of the learning curve in the field of architecture was in the 1965 European Economic Commission report, Effect of Repetition on Building Operations and Processes on Site [3]. From this report on, various applications of learning curves have emerged in the field of architecture, such as prestressed concrete columns, formwork, and reinforcement. The learning curve is also applied to the various phases of the construction project, such as design [4], bidding [5], planning [6], and even claim management [7-8]. The same learning curve also corresponds to whether the construction project is feasible. Many scholars use these learning curves to analyze whether a construction project is feasible. Some scholars have made an empirical study of the learning effect in the field of construction. Jarkas and Horner used the intermittent observation method to collate the relevant data and found that even increasing the number of jobs per unit did not improve their work efficiency but partially decreased it [9].

Despite the fact that the importance and relevance of using the learning curve in the construction industry are well understood, there is a scarcity of literature to explain this issue [10]. Because appropriate research, planning, and feasibility-based resource allocation are the most basic ways a construction project can obtain the benefits of its use, a model suitable for historical data with acceptable prediction ability to apply in the construction industry is required.

The project feasibility study is a detailed technical and economic demonstration based on a variety of comparisons and optimizations, and the project investment is in the final decision conclusion. The detailed feasibility study, also called the final feasibility study, belongs to the in-depth feasibility study. It is an important stage of the investment decision process, which can be made through advanced technology, economic rationality, and financial for-profit demonstration. Then the investment in the engineering project can be concluded. Feasibility studies of existing vision-based methods are applied to construction sites. The vision-based building techniques include scene analysis, activity recognition, object tracking, and object detection. These four categories of vision-based techniques have been the foundation for the development of numerous building applications [11-13]. The initial stage of many vision-based investigations in construction, object-detection algorithms retrieve the localisation and categorical information of construction objects (e.g., machines, workers, and materials) from construction photos or videos [14].

In total, the existing research mainly includes that the learning curve is applied in the construction aspect or every stage of the construction project. The learning curve is used to analyze whether the construction project is feasible. However, researchers did not investigate the application of the learning curve in the project cost estimation and did not discuss whether the construction project is feasible and the correlation of the learning curve and the construction project. Hence, we specifically analyze the construction project costs by using the learning curve.

3. Model Discussion

A one-factor learning curve model and a two-factor learning curve model are the two fundamental types of learning curve models. The project feasibility study is examined in this research using the one-factor learning curve model.

The learning curve model is established according to the application conditions of learning curve theory and the current situation of feasibility in building projects. According to the feasibility learning curve model, the reduction in project unit area cost is the result of the increase in cumulative construction area. The learning rate indicates the influence of the cumulative construction area on the cost per unit area. The greater the learning rate, the more the cost per unit area decreases with the increase in the cumulative construction area, and vice versa.

DOI: 10.54254/2754-1169/27/20231251

Analyzing the relationship between the cost per unit area of the construction project and the cumulative construction area, the basic model of the construction industry learning curve is as follows:

$$A(s) = B(s) + C(s) + D$$

In the formula, A (s) represents the relationship between total cost and construction area, B (s) represents the relationship between material cost and construction area, C (s) represents the relationship between construction cost and construction area, and D represents the management fee. This model regards the management fee as a fixed value and does not change with the change in building area. S is the construction area and $C(s) = C_1 \cdot \sum_{l=1}^{s} l^{-a}$,$B(s) = bS$

S is the floor area, C1 is the initial construction cost, and a is the learning index of the construction area to the unit cost (0 <a <1). The cost of b is the required material cost per unit of floor area.

In the simulation model of the construction area per 100 square meters, it is 100 square meters to 1000 square meters respectively. When the construction area is 100 square meters, the management fee is assumed, the initial cost is 100 yuan, and the material cost is 200 yuan. By the above formulae, the relevant data is as follows:

Table 1: Construction cost simulation.

Material fee/¥	Cost of operation/¥	Initial construction cost/¥	Building area/100 square meters	Total cost A/¥(a=-0.7)	Total cost A/¥(a=-0.9)	Construction fee/¥(a=-0.7）	Construction fee/¥(a=-0.9)
200	100	100	1	400	400	100.00	100
200	100	100	2	661.56	653.59	161.56	153.59
200	100	100	3	907.90	890.79	207.90	190.79
200	100	100	4	1145.80	1119.51	245.80	219.51
200	100	100	5	1378.21	1343.00	278.21	243.00
200	100	100	6	1606.74	1562.94	306.74	262.94
200	100	100	7	1832.35	1780.29	332.35	280.29
200	100	100	8	2055.68	1995.68	355.68	295.68
200	100	100	9	2277.16	2209.53	377.16	309.53
200	100	100	10	2497.11	2422.11	397.11	322.11

As can be seen from the table, the cumulative construction area of construction projects increases year by year, but the increase rate decreases year by year; as the cumulative construction area of construction projects increases, the cost per unit area decreases year by year, and the decrease rate becomes smaller and smaller. This also further proves that, from the feasibility study of the project, the cumulative construction area and the unit cost can be studied.

DOI: 10.54254/2754-1169/27/20231251

4. Discussion

To choose the best learning model, the tool mines the input data. The tool's collection of learning curve models takes into account how different each building job is. The programme accepts MS Excel spreadsheets as project task inputs and provides the user with estimations of task durations for a specified number of these repeated jobs. The automatic work time prediction tool is totally dependent on Microsoft Excel macros, making it usable on any laptop that construction professionals frequently use. This program offers precise time estimates for building projects without the need for hardware or software changes, which may be useful to practitioners.

To expand the current model, numerous learning curve models can be considered, which have appeared in the literature since T.P. Wright introduced the first one in 1936 [15]. The type and complexity of the models that have been published in the literature vary; reviews of learning curve models that have been published in the literature can be found in Anzanello and Fogliatto and Srour et al [16,17]. The Wright model, the exponential model, the hyperbolic model, and the recursive model are four learning curve models that can be incorporated into the newly created tool. These models were chosen because they are applicable to the construction sector and have previously shown to be capable of performing in terms of fitness (their capability to fit historical data) and predictability (their capacity to estimate future data) [17].

There is no new tool that can independently estimate construction costs. Although the tool was able to produce exceptional results, those results might be on par with those produced by other tools already in use. A variety of scheduling techniques can be employed to gauge how long recurring construction tasks will take. These techniques range from straightforward ones like linear scheduling algorithms to more sophisticated ones like probabilistic procedures. For instance, Ammar [18] combined the critical path method (CPM) and line-of-balance (LOB) to schedule projects with recurring operations. On the other hand, Maravas and Pantouvakis [19] built on the RSM and utilized a higher order fuzzy approach to estimate the time of repetitive operations.

Learning curve theory and probability distributions are combined in other nondeterministic strategies for scheduling repetitive tasks.To assess the lengths of intermittent exercises, Hijazi et al [20]. A stochastic learning curve model was suggested by in 1992.Panas and Pantouvakis utilized learning curve theory in conjunction with simulation to estimate performance in activities involving the construction of floating caissons [21]. The probabilistic methods utilized by Panas, Pantouvakis, and Hijazi et al. are compared to the suggested tool's effectiveness. [20-21]. These methods were picked in light of the fact that both the technique took on by the apparatus and the one utilized in these two examinations depend on expectation to learn and adapt hypothesis.

A task duration estimation tool with a tolerable forecast error that can be used to create construction schedules is suggested by this study.Using well-established learning curve models, the program calculates future task duration estimates.This work extends previous research on the application of learning curve models to task length estimations for automated scheduling by incorporating a collection of learning curve models that are automatically calibrated to the project history.

5. Conclusion

The paper used the theoretical method of a learning curve and used some simulated data to obtain the building project cost. According to the learning curve, the construction cost changes with the cumulative construction area, and then the total cost of the construction project is projected.

The cumulative output of the project's continual cost reduction reveals that the quality of the construction staff has a reasonably significant impact on the industry's cost reduction. The cost of China's construction industry has been discovered to be influenced by a number of other factors other

DOI: 10.54254/2754-1169/27/20231251

than labor experience, and these other factors will be more important than labor experience for some time in the future (two-factor learning model). However, at this point, with the enterprise's cost strategy in mind, training staff to increase productivity and quality of work is the most crucial method for saving costs for the company.

References

[1] ARROW K J. Economic implication of learning by doing［J］. Review of Economic Studies，1962，29 (3) : 155 －173． Author, F., Author, S.: Title of a proceedings paper. In: Editor, F., Editor, S. (eds.) CONFERENCE 2016, LNCS, vol. 9999, pp. 1–13. Springer, Heidelberg (2016).

[2] ROSENBERG N. Perspectives on technology［M］. Cambridge: Cambridge University Press，1976 (6): 125－127．

[3] Nations, U. (1965). "Effect of repetition on building operations and processes on site: Report of an enquiry." ⟨http://books.google.com.lb/ books?id=5cV8QgAACAAJ⟩ (Nov. 5, 2015).

[4] Hamade, R. F., Jaber, M. Y., and Sikström, S. (2009). "Analyzing cad competence with univariate and multivariate learning curve models." Comput. Ind. Eng., 56(4), 1510–1518.

[5] Wong, P. S., On Cheung, S., and Hardcastle, C. (2007). "Embodying learning effect in performance prediction." J. Constr. Eng. Manage. 133:6(474), 474–482 (2007).

[6] Zhang, L., Zou, X., and Kan, Z. "Improved strategy for resource allocation in repetitive projects considering the learning effect." J. Constr. Eng. Manage (2014).

[7] Lam, K. C., Lee, D., and Hu, T. (2001). "Understanding the effect of the learning-forgetting phenomenon to duration of projects construction." Int. J. Proj. Manage., 19(7), 411–420.

[8] Hinze, J. and Olbina, S. "Empirical analysis of the learning curve principle in prestressed concrete piles." J. Constr. Eng. Manage., 425–431 (2009).

[9] JARKAS A，HORNER M． Revisiting the applicability of learning curve theory formwork labor productivity［J］． Construction Management and Economics，2011 (29): 483－493．

[10] Thomas, H. R. "Construction learning curves." Pract. Period. Struct. Des. Constr., 14:1(14), 14–20 (2009).

[11] Roberts, D., and M. Golparvar-Fard. "End-to-end vision-based detection, tracking and activity analysis of earthmoving equipment filmed at ground level." Autom. Constr. 105 (Sep): 102811 (2019).

[12] Son, H., H. Seong, H. Choi, and C. Kim. 2019. "Real-time vision-based warning system for prevention of collisions between workers and heavy equipment." J. Comput. Civ. Eng. 33 (5): 1–14.

[13] Wang, X., and Z. Zhu. "Vision-based hand signal recognition in construction: A feasibility study." Autom. Constr. 125 (Feb): 103625 (2021).

[14] Kulchandani, J. S., and K. J. Dangarwala. "Moving object detection: Review of recent research trends." In Proc., Int. Conf. on Pervasive Computing, 1–5. New York: IEEE (2015).

[15] Jaber, M. Y. Learning curves: Theory, models, and applications. Boca Raton, FL: Taylor & Francis Group (2016).

[16] Anzanello, M. J., and F. S. Fogliatto. "Learning curve models and applications: Literature review and research directions." Int. J. Ind. Ergon. 41 (5): 573–583 (2011).

[17] Srour, F. J., D. Kiomjian, and I. M. Srour. "Learning curves in construction: A critical review and new model." J. Constr. Eng. Manage. 140 (1): 06015004 (2015).

[18] Ammar, M. A. "LOB and CPM integrated method for scheduling repetitive projects." J. Constr. Eng. Manage. 139 (1): 44–50. (2013)

[19] Maravas, A., and J.-P. Pantouvakis. "Fuzzy repetitive scheduling method for projects with repeating activities." J. Constr. Eng. Manage. 137 (7): 561–564 (2011).

[20] Hijazi, A. M., S. M. AbouRizk, and D. W. Halpin. 1992. "Modeling and simulating learning development in construction." J. Constr. Eng. Manage. 118 (4): 685–700 (1992).

[21]]Panas, A., and J. P. Pantouvakis. "Simulation-based and statistical analysis of the learning effect in floating caisson construction operations." J. Constr. Eng. Manage. 140 (1): 04013033 (2014).