Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 164 (2016) 90 – 97

Procedia Engineering

www.elsevier.com/locate/procedia

Creative Construction Conference 2016, CCC 2016, 25-28 June 2016

Learning Curve Effect on Project Scheduling

Levente Malyusz*

Budapest University of Technology and Economics, Muegyetem rkp. 3. Budapest 1111, Hungary

Abstract

In this paper a simple learning curve effect on project scheduling is shown with a help of an artificial example. Although learning is an essential part of our life, traditional scheduling technique can not handle efficiently the learning curve effect. It is assumed that the duration of upcoming repetitive activities are shorter due to the learning curve effect if the gap between consecutive activities is small enough. Learning curve theory can be applied to predicting cost and time to complete repetitive activities. Taking into accounts the effects of learning curve (or experience curve) one can get better future prediction on project duration and can save money and time. This effect normally result in shorter project duration. Although the effect is "simple" calculations are cumbersome if the learning effect is applied on traditional project scheduling techniques like Critical Path Method, or Precedence Diagramming Method as calculation lead to an exponential time algorithm.

Peer-review under responsibility of the organizing committee of the Creative Construction Conference 2016
Keywords: learning curve; project scheduling; precedence diagramming method

1. Introduction

In practice project scheduling methods suffer from lack of precision therefore it is a big challenge to create a realistic and useable project schedule. It is difficult and time consuming to properly estimate time, assign resource, determine interdependencies between tasks, manage changes… That is why it is important to discover and investigate the differences between practice and theory of scheduling methods (Francis et al. [1]). In a construction project general contractor distributes the job among subcontractors. It is an observation that subcontractors rarely start their work at earliest possible time. It is obvious that they can reduce their cost if they work continuously.
According to the theory of learning when numerous similar or nearly identical tasks are performed, the necessary

* Corresponding author. Tel.: +37 -70-290-5210;
E-mail address: lmalyusz@ekt.bme.hu

Peer-review under responsibility of the organizing committee of the Creative Construction Conference 2016
doi:10.1016/j.proeng.2016.11.596

effort is reduced with each successive task (Oglesby et al. [2], Drewin [3], Teplitz [4], Everett and Farghal [5,6], Lutz et al. [7], Lam et al. [8], Couto and Teixeira [9]). Learning curve theory can be applied to predicting the cost and time, generally in units of time, to complete repetitive activities (Malyusz and Pém[10]). Based on the theory basically there are two different methods of calculation the activity time of repetitive activities. Unit time and the cumulative average time methods. Unit time method means that the time of some doubled unit equals the time of the undoubled unit times the slope of the learning curve. Cumulative average method means that the cumulative average time of some doubled unit equals the cumulative average time of the undoubled unit times the slope of the learning curve. This was used in the original formulation of the learning curve method, referred to as Wright's model, in Wright's famous paper on the subject [11]. A number of researchers have suggested that Wright's model is the best model available for describing the future performance of repetitive work (Everett and Farghal [5], Couto and Teixeira [9]). In (Malyusz and Pém [12]) the exponential average method with α =0.5 yielded the most accurate predictions.
In construction project management the proper scheduling of project is an essential problem. Estimation of activity's time is a crucial part of the schedule. Learning curves impact activity's time and in recently used management softwares, which can handle resources, this effect would be handled easily (Hajdu [14], [18]). The objective of this paper is to show an effect of learning curve that can cause changes in project duration. This occurs when the same construction team performs similar activities continuously, so after finishing of the predecessor activity successor can immediately start.
There is little information in the literature about the use of learning curves in scheduling, although it seems that the principle of learning curves gathers its ground in scheduling of repetitive construction operations (Hinze and Olbina [15], Fini et al. [17]). In (Zahran et al.[16]) learning curve effect on linear scheduling method is discussed.

1.1. Learning curve

Learning curve theory is applicable to the prediction of the cost or time of future work, assuming repetitive work cycles with the same or similar working conditions in terms of technology, weather, and workers, without delay between two consecutive activities. The direct labor required to produce the (x + 1)st unit is assumed to always be less than the direct labor required for the x^{th} unit. The reduction in time is a monotonically decreasing function, an exponential curve, as described in Wright's [11] paper.

Wright's linear log x, log y model is as follows:

$$ln y = ln a + b ln x; \vee\ y = ax^b = ax^{log_2 r} \quad (1),$$

where x is the cycle number, y is the time required to complete cycle x in labor hours/square meter, a is the time required to complete the first cycle, b is a learning coefficient, and r is the rate of learning. For example if r=0.9 (90%), then b=-0.151 see Figure 1. Wright discovered that when the labor cost decreases at a constant rate, that is, the learning rate, the production/cycles doubles. So learning rate is the constant rate with which labor time/cost decreases when the production/cycles doubles in a linear log x, log y model. This feature of the learning rate comes from the logarithms nature and true only in linear log x, log y model.