Avrupa Bilim ve Teknoloji Dergisi
Özel Sayı, S. 137-143, Nisan 2020

Araştırma Makalesi

www.ejosat.com ISSN:2148-2683

European Journal of Science and Technology
Special Issue, pp. 137-143, April 2020

Research Article

Case Study for Getting Probability Distributions of Some Basic Construction Activities**

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(Conference Date: 5-7 March 2020)

(**DOI:** 10.31590/ejosat.araconf18)

ATIF/REFERENCE: Gürbüz, F., Dinç, M., & Erdinç, G. (2020). Case Study for Getting Probability Distributions of Some Basic Construction Activities. *Avrupa Bilim ve Teknoloji Dergisi*, (Özel Sayı), 137-143.

Abstract

Under the title 'Management', it should be considered many things simultaneously such as time, money, manpower, machinery and equipment and their interactions. After that consideration, it should have also optimized them to improve the workflow, scheduling, resource usage etc. Well, it is not easy in the uncertain environment of construction sector, which has a many stakeholder, has long completion times and is highly dependent on the human labor. It is necessary to model this uncertainty. Most importantly, we need the probability data for these models. In this study a housing project consisting of 13 floors was analyzed, the completion times of 20 activities are given for each of these floors and the distribution of the duration of each activity implemented on each floor was obtained. Those activities are repeated 13 times by the same team and with the same equipment. According to that results, activities mainly fit the Logistic, Log Logistic, Lognormal and Weibull distribution. After determining that which distribution for the activities is best suited to our data, the real time data is adjusted to this distribution and the average completion time of this activity for this building is obtained. Based on the average completion time of each activity, the completion time of the entire building was obtained.
The aim was getting the stochastic data from a real project to use in different management stage in future. Besides, the number of samples will also be increased and the deviations in the resulting distributions and their causes will be examined.

Keywords: Construction management, Probability distribution, Project planning.

Bazı Temel İnşaat Faaliyetlerinin Olasılık Dağılımlarının Alınmasına İlişkin Örnek Olay

Öz

'Yönetim' başlığı altında, zaman, para, insan gücü, makine ve ekipman ve bunların etkileşimleri gibi birçok şey eşzamanlı olarak ele alınmalıdır. Bu değerlendirmeden sonra, iş akışı, zamanlama, kaynak kullanımını gibi yönetimi etkileyen faktörleri geliştirmek amacıyla bahsedilen yönetim başlığı altındaki bileşenlerin iyileştirilmesi gerekmektedir. Diğer taraftan bakıldığında pek çok paydaşı olan, uzun tamamlanma süreleri sözkonusu olan ve yüksek oranda insan emeğine bağımlı olan inşaat sektörünün belirsiz ortamında bunu gerçekleştirmek kolay değildir. Bu belirsizliği modellemek gerekir. Bu bağlamdaki en önemli faktör, bu modeller için olasılık

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** This paper was presented at the ***International Conference on Access to Recent Advances in Engineering and Digitalization (ARACONF 2020)***..

verilerine ihtiyacımız vardır. Olasılık verilerimize en uygun dağılıma göre, bu verilerden gerçek zamanlı veriler elde ederiz. Bu çalışmada 13 kattan oluşan bir konut projesi analiz edilmiş, bu katların her biri için 20 faaliyetin tamamlanma süresi verilmiş ve her katta gerçekleştirilen her faaliyetin süresinin dağılımı elde edilmiştir. Bu faaliyetler aynı ekip tarafından ve aynı ekipmanla 13 kez tekrarlanır. Sonuçlara göre; faaliyetler çoğunlukla Lojistik, Lojistik Lojistik, Lognormal ve Weibull dağılımına uygun sonuç vermiştir. Faaliyetler için hangi dağılımın verilerimize en uygun olduğunu belirledikten sonra, gerçek zamanlı veriler bu dağılıma göre ayarlanır ve bunun sonucunda ilgili binada bu faaliyetinin ortalama tamamlanma süresi elde edilir. Her faaliyetin ortalama tamamlanma süresine bağlı olarak, tüm binanın tamamlanma süresi elde edilmiştir. Amaç, gerçek bir projeden alınan stokastik verileri gelecekte farklı yönetim aşamasında kullanmaktır. Çünkü çok katlı binalardan oluşan karmaşık yapılar üzerinde çalışmalar yapıldığında, proje yönetiminin tüm faaliyetlerin zaman verilerini kullanarak projenin tamamlanma süresini elde etmesi çok yararlı olacaktır. Özetle; zaman verilerine parametrik testler uygulanacaktır. Her kat için tüm katsayıların zamanlarının dağılımları incelenecek ve sonuçlar belirlenecek ve elde edilen sonuçlar hakkında gerekli yorumlar yapılacaktır. Ayrıca, örnek sayısı artırılacak ve ortaya çıkan dağılımlardaki sapmalar ve nedenleri incelenecektir.

Anahtar Kelimeler: Yapı yönetimi, Olasılık dağılımı, Proje planlama.

1. Introduction

Project Management is a phenomenon that has been going on for many years and its content has not changed much. In other words, using time, money, manpower, machinery and equipment in the most efficient way is defined as efforts to complete the purpose in the best time with the most appropriate budget. Today, it is not the changing objective, but the tools and the type of data of these tools (Avenal, 2014).

The success of management depends on the modeling of the system with all variables. However, it is not easy in construction sector where there are many variables that vary depending on different scenarios. Therefore, the probabilistic data are now used in many fields of construction management.

In this context, a housing project consisting of 13 floors was analyzed and the distribution of the duration of each activity implemented on each floor was obtained. The aim was getting the stochastic data from a real project to use in different management stage in future.

In the literature research we conducted, there are many studies under the subject titles such as project management, project scheduling, project or activity duration. Some of these studies, especially those made in recent years, are given below.

Chen, Ding, Zhang, J. & Qin, 2019 studied on new project arrival and stochastic duration in dynamical RCMPSP using a systematic research.

Gonzalez-Ruiz et al., 2019 proposed a Stochastic Fuzzy Logistic Model for patterning the construction of integrated mutilates scenarios in the financing of infrastructure projects.

Ma, Demeulemeester, He, and Wang, 2019 addressed the proactive resource-constrained project scheduling problem, for exploring the better surrogate robustness measures to generate robust baseline schedules under uncertain platforms.

Creemers, 2019 studied the preemptive stochastic resource-constrained project scheduling problem (PSRCPSP), and present an exact solution procedure.

Tao, Wu, Sheng, and Wang, 2018 studied a resource constrained project scheduling problem with hierarchical alter- natives and stochastic activity durations.

Chen et al., 2018 examined the performance of 17 priority rule heuristics and the justification technique on the stochastic resource-constrained project scheduling problem.

Tao et al., 2018 investigated a resource-constrained project scheduling problem that involves alternative methods and stochastic activity durations.

Wanga, He, Kerkhove, and Vanhoucke, 2017 assumed the activity duration as a stochastic variable and propose two new robustness measures to analyze the performance of priority rules under a stochastic environment.

Ning, He, Jia, and Wang, 2017 investigated the multi-mode cash flow balanced project scheduling problem with stochastic duration of activities for generating a robust baseline schedule to minimize the contractor's maximal cumulative gap between cash outflows and cash inflows.

Wood, 2017 studied on critical path and crucial work items than standard earned schedule and earned duration metrics to calculate earned duration and related duration performance index for critical path items weighted for their planned duration.

Ke, Maa, and Chen, 2012 introduced a stochastic time-dependent time–cost trade-off problem is meet different management requirements; three stochastic time–cost trade-off models are built.

Rabbani, Ghomi, Jolai and Lahiji, 2007 presented a newly developed resource-constrained project scheduling method in stochastic networks that merges the new and traditional resource management methods.

Ke and Liu, 2005 considered a project scheduling problem with stochastic activity duration times, minimizing the total cost under some completion time limits.

Salimi, Mawlana, and Hammad, 2018 claimed that there is a need for simulation during the analysis and planning of the project due to the uncertainty and variability of the projects. Ballesteros-Perez et al. claimed that the main reason for this difference was poor planning control.

Durucasu, Karamaşa, İcan, Yeşilaydın, and Gülcan, 2015 emphasized the importance of the study of fuzzy numbers instead of exact numbers instead of the exact numbers of the fuzzy CPM method instead of the classical CPM method commonly used in the literature.

Bayhan, Kanra, Demir, Kar, and Gürcanlı, 2016 performed estimated efficiency calculations of future projects using stochastic models that were previously performed but not outdated.

This study consists 5 parts:

Firstly, attention was paid to the specific structure of construction management and the requirements for using probabilistic data to work in this field with relavant literature review as introduction. After that as second part, the methodology was presented step by step with some prints from Minitab 17 Statistical Software. Sections 3 and 4 contain results and conclusions. In conclusion, it can be found the interpretation of results and connections with future studies. As the last, the references were given.

2. Material and Method

In this study, the operations on 13 floors of a building are discussed. The completion times of 20 activities such as wall flooring and concrete flooring are given for each of these floors. As these times vary between floors, it cannot be predicted how long each operation will last throughout the building.

Therefore, the aim of this paper is to find the average completion time of the activities by analyzing this time data and to find the completion time of the building including all floors.

Here the project consists of a single small building. However, when studies are conducted on complex structures consisting of many multi-story buildings, it will be very useful for project management to obtain the completion time of the project by using time data of all activities.

In summary, parametric tests will be applied to the time data, the distributions of the times of each activity for all floors will be examined and the results will be determined, and the necessary comments will be made about the results obtained. The application was performed in Minitab 17 Statistical Software.

2.1. Distributions by Activities

We use distribution ID Plot to determine which distribution best fits our data by comparing how closely the plot points lie to the best-fit lines of a probability plot.

Anderson-Darling is used for the least squares and maximum likelihood estimation methods. The smallest Anderson Darling value indicates which distribution best fits the data.

The following table and graphes show that the most appropriate distribution for wall flooring activity is 'Logistics' with the smallest value. For the time data entered, 13 are insufficient and cannot create large differences between distributions.

Table 1. Wall Flooring

Floors	1	2	3	4	5	6
Duration (days)	12,92	13,8	10,25	12,8	12,2	14,5
7	8	9	10	11	12	13
11,75	11,5	12,2	11,9	9,25	10,25	9,75

Table 2. Result of Anderson-Darling Distribution

Goodness-of-Fit	
Anderson-Darling	
Distribution	(adj)
Weibull	1,178
Lognormal	1,230
Exponential	5,108
Loglogistic	1,160
Normal	1,193
Logistic	1,160

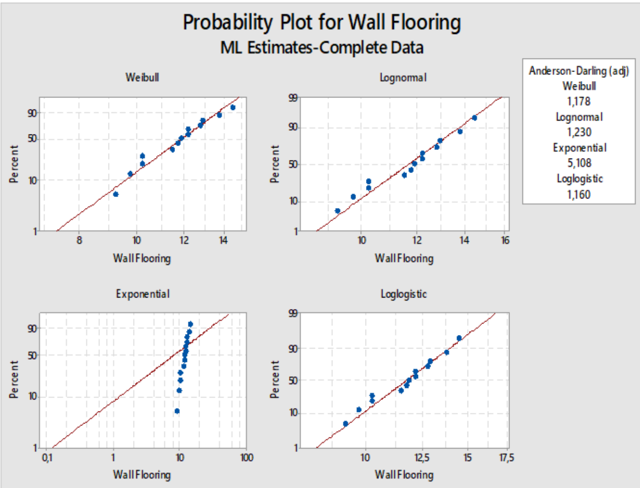

Figure 1.Probability Plot for Wall Flooring

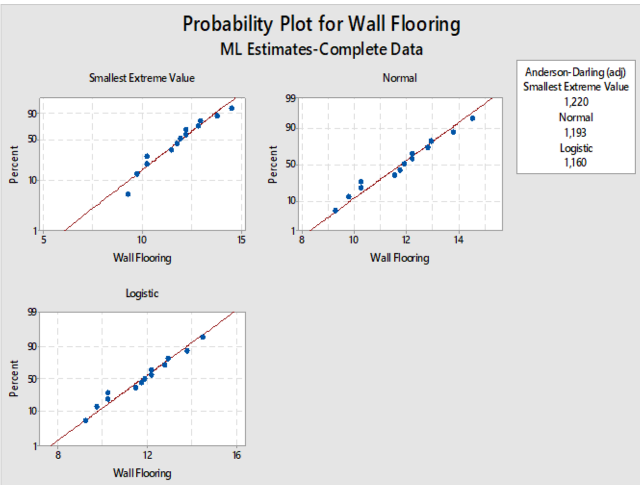

Figure 2.Probability Plot for Wall Flooring

All outputs are given in detail for the first activity. In the above graphs we can observe the probability graphs to determine the appropriateness of the distribution to the data. After determining that the logistic distribution for this activity is best suited to our data, the real time data is adjusted to this distribution and the average completion time of this activity for this building is obtained.

Parametric distribution analysis-right censoring was used for this purpose and 'logistic' was selected for the assumed distribution. If our data include exact time data or if test units do not fail before our study is over, that means our data are right-censored. We can fit one of lots of common distributions to our data which are located in Goodness-of-Fit. According to our results below, parameter estimates, their standard errors, confidence intervals were obtained.

Table 3. Result of Distribution Analysis: Wall Flooring

Distribution Analysis: Wall Flooring

Variable: Wall Flooring

Censoring Information Count Uncensored value 13

Estimation Method: Maximum Likelihood

Distribution: Logistic

Parameter Estimates

		Standard	95,0% Normal CI	
Parameter	Estimate	Error	Lower	Upper
Location	11,7942	0,435200	10,9413	12,6472
Scale	0,889830	0,203112	0,568869	1,39188

Log-Likelihood = -24,169

Goodness-of-Fit

Anderson-Darling (adjusted) = 1,160

Characteristics of Distribution

		Standard	95,0% Normal CI	
	Estimate	Error	Lower	Upper
Mean(MTTF)	11,7942	0,435200	10,9413	12,6472
Standard Deviation	1,61397	0,368404	1,03181	2,52459
Median	11,7942	0,435200	10,9413	12,6472

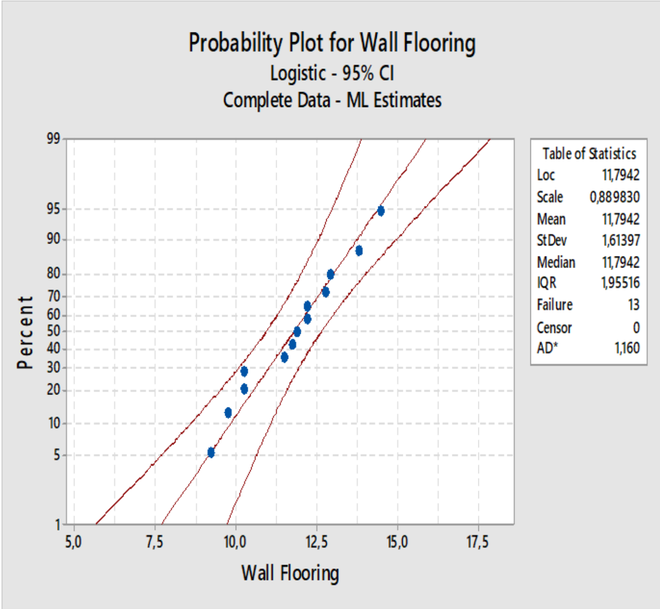

Figure 3.Probability Plot for Wall Flooring, Logistic- 95% CI

In addition, we can observe from the last graph that the time data for wall flooring remains within the 95% confidence interval limits. Nevertheless, the important thing for us is the mean duration of the activity to be obtained from the distribution characteristics. From the sum of these periods to be obtained for each activity, the complete period of completion of all works in the building can be reached.

3. Results and Conclusions

For wall flooring, the solution steps and obtaining the required time are described in detail above. Similar applications for all activities were carried out in Minitab and the results are given in the table 2 below.

Table 4. Minitab Outputs of Activities

Activities	Distribution best fits the data	Mean	Standard Deviation
1.Wall flooring	Logistic	11,7942	1,61397
2.Concrete flooring	Lognormal	11,8560	1,20380
3.Interior wall trim	Loglogistic	10,5958	1,10859
4.Electric infrastructure	Loglogistic	11,7584	1,16531
5.Hydraulic infrastructure	Lognormal	11,7476	1,07909
6.Windows	Lognormal	3,47943	0,67251
7.Drywall	Lognormal	6,96070	0,82287
8.Water insulation	Lognormal	5,79893	1,19551
9.Ground leveling	Lognormal	5,79893	1,19551
10.Complete plaster	Lognormal	6,26373	1,40758
11. Tiles wall	Lognormal	6,22609	1,35478
12. Floor tiles	Lognormal	6,28550	1,31217
13.Plaster ceiling	Loglogistic	5,25454	0,29921
14. Cleaning	Weibull	4,46567	0,47619
15.Doors	Logistic	5,27009	0,21853
16.1st floor paint	Weibull	4,46567	0,47619
17.2nd floor paint	Weibull	4,46567	0,47619
18.End of electrical work	Weibull	4,63748	0,51161
19. Plumbing	Logistic	5,12427	0,53776
20.Final cleaning	Weibull	4,46567	0,47619

In this study a housing project consisting of 13 floors was analyzed, the completion times of 20 activities are given for each of these floors and the distribution of the duration of each activity implemented on each floor was obtained. Those activities are repeated 13 times by the same team and with the same equipment.

According to that results, activities mainly fit the Logistic, Log Logistic, Lognormal and Weibull distribution. After determining that which distribution for the activities is best suited to our data, the real time data is adjusted to this distribution and the average completion time of this activity for this building is obtained.

4. Conclusion

This paper presents a case study to obtain probability distributions for some basic construction activities from a housing project. Those activities are repeated 13 times by the same team and with the same equipment. The results are given in third part.

According to that results activities mainly fit the Logistic, Log Logistic, Lognormal and Weibull distribution. As we said before for the time data entered, 13 are insufficient and cannot create large differences between distributions.

Based on the average completion time of each activity, the result of the completion time of the entire building lasts approximately 136.7 days.

In future, the resulting distributions will be used for planning of the project. Besides, the number of samples will also be increased and the deviations in the resulting distributions and their causes will be examined.

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