Greener Journal of Environment Management and Public Safety

ISSN: 2354-2276

Vol. 13(1), pp. 188-193, 2025

https://gjournals.org/GJEMPS

DOI: https://doi.org/10.15580/gjemps.2025.1.032725066

Project Evaluation for Digitalization of Manufacturing Process Using Combination of PERT and CPM Approach in Snell X Cloud Enterprise Resource Planning Company

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ABSTRACT

Digital transformation has the potential to drive economic growth by enhancing productivity, efficiency, and innovation. Cloud Enterprise Resource Planning (CERP) is one of the digital mediums that can support Small and Medium Enterprises (SME). By integrating all resources and information into a single platform, CERP systems can provide SME owners with a comprehensive overview of their entire business processes and enable more informed decision- making. However, a lack of careful planning before starting the CERP implementation project can lead to delays. The implementation of the CERP project by Snell X was scheduled to be completed by August 2021 but did not meet the target. Technical challenges, such as integration with existing systems, configuration errors, or system performance issues, can result in suboptimal digitalization of business processes. By combining the Critical Path Method (CPM) and the Project Evaluation and Review Technique (PERT) for scheduling and project evaluation, companies can plan and implement CERP more effectively, efficiently, and timely. The results of using CPM and PERT in this case revealed that the duration of the digitalization project for SME manufacturing processes with CPM was 29 days, compared to the previous existing project that took 39 days. CPM helps identify critical paths that allow the company to focus on crucial tasks to determine project completion time efficiently. Meanwhile, PERT provides more accurate time estimates and various project scenarios, assisting management in planning and dealing with uncertainties that may arise during project implementation. The combination of both methods helps SME save time and resources, improve productivity, and achieve project goals more effectively.

ARTICLE'S INFO

Article No.: *032725066*
Type**:** *Research*
Full Text: *PDF, PHP, MP3*
DOI: *10.15580/gjemps.2025.1.032725066*

Accepted: *02/04/2025*
Published: *30/07/2025*

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Keywords: *Cloud Enterprise Resource Planning, Manufacturing Process, Digitalization, PERT and CPM Approach, Snell X, Project Evaluation and Review Technique, Critical Path Method*

1. INTRODUCTION

Since 1990, numerous businesses have used the ERP system to deploy it in order to maximize their competitive advantages. However, not all of them are capable of performing this. Because the adoption of information technology was not entirely effective (Christiansen et al., 2022), some businesses saw a fall in profitability, lost their position as industry leaders, and some even had to declare bankruptcy (Haddara et al., 2022). In 1996, FoxMeyer Corp neglected to take proper care during the implementation of the ERP system (Hole, 2022), and W. W. Grainger, Inc. made a mistake while calculating warehouse inventory (Itagi et al., 2023). Because of the advantages an ERP system will have for the organization in the long run, other businesses continue to pursue their plans to deploy the system (Hansen, 2023).

The quality and effectiveness of customer service, production, and distribution may all be significantly improved with the assistance of ERP systems, which may provide a framework for integrating and enhancing a business' internal business operations. The cost of transaction processing for staff members who maintain hardware, software, and information technology can be lessened with an ERP system. ERP systems may facilitate it less difficult to make decisions (Hansen, 2023) and perform managerial responsibilities (Molina-Castillo, 2022).

The SME that is the focus of this study intends to deploy an ERP system for the reasons listed: First, material losses as a result of discrepancies between stock reports and unrecorded inspections; Second, a lack of an information system that integrates existing departments; Third, the continued use of the traditional customer sales order process; and the last is the absence of an early warning system for when inventory needs to be replenished. Unfortunately, there were problems with the ERP installation project when it was deployed in SME. Due to the lack of clarity in the project's implementation, this plainly resulted in losses to the extent that the corporation was forced to halt the project.

However, through the Critical Path Method (CPM), researchers can determine the dependency relationships between activities and determine which activities (referred to as critical activities) have a tolerance for delay times and which activities do not. In addition, researchers determined the proportion of projects that were scheduled using the developed CPM approach that were completed on time using the Project Evaluation and Review Technique (PERT) method (Haekal et al., 2023).

2. METHODS

This study employs a quantitative methodology and includes project scheduling information from the team of information systems providers as well as data gleaned from observations. In order to better understand the phenomena that take place during the ERP implementation project, this research also employs a qualitative approach by conducting interviews with a variety of sources involved in the project (Gray, 2020).

The gathered main and secondary data are then processed in order to identify work networks, identify important paths, optimize ERP project scheduling using the CPM method, and analyze the probability of project completion on time. Determining the sequence of activity dependencies (Predecessor), Creating a Work Network, and Finding the Critical Path are the steps to creating a schedule project using the CPM method. Meanwhile, PERT follows nearly the same stages as CPM (Bagshaw et al., 2021), because PERT must also look for important path activities. In PERT, the critical path or flow is referred to as slack (Mukul et al., 2019). The activity duration estimation, which uses three project completion estimations, demonstrates the distinction between CPM and PERT. The three-time estimates in PERT are as follows: Optimistic Duration Time (Ta); Most Likely Time (Tm); Pessimistic Duration Time (Tb).

2.1. Data Collection

The ERP system implementation team uses the Gantt chart scheduling approach to estimate the amount of time needed to perform the project (Mourtzis et al., 2020). The internal team kick-off meeting, project planning, client kickoff meeting, VPS and Odoo 14 installation process, business process analysis (as is), business process analysis (to be), making blueprint, prototyping, prototype testing, user training creation, user training, and go live are just a few of the activities that are carried out for the data collection process. In the meantime, the ERP implementation team provides a Gannt Chart with the duration of each activity.

2.2. Data Processing

In order to obtain the best outcomes (shortest processing time and highest success probability), the researcher calculated the CPM and PERT procedures utilizing two alternatives. Option 1 involved figuring out the CPM and PERT methodologies based on the order of activity dependencies and the number of available personnel. Option 2 involves computing the CPM and PERT methodologies based on the dependence order of the activities and the proposed staff capacity.

The first stage in the CPM method is to establish a functional network by first figuring out the dependencies between tasks (predecessors) based on dependency logic through brainstorming with the ERP implementation team. The project activities' order is then reorganized into a Work Network Diagram after the sequence of dependencies has been determined. By segmenting the project scope into activities or activity groups, the project components are recognized. The next stage is to

reorder the activities into a chain so that we can determine the order of activities from the beginning to the end of the entire project. Thus, we can use formulas (1) and (2) to obtain the forward calculation. From the initial event through the last event, the forward computation progresses. The point is to calculate the fastest event, the fastest commencement and the completion of activities (TE, ES, and EF).

$TE(j) = ES(i,j) = 0$ (1)

$EF(i,j) = ES(i,j) + t(i,j)$ (2)

ES : The fastest start of activity TE : The fastest event

EF : The fastest completion of activity t Time required for an activity

The countdown calculation using the formulas (3) and (4) comes after the forward computation. The initial event is where the countdown calculation shifts from the event endpoint. The objective is to calculate the latest event, the latest commencement and completion of activities (TL, LS, and LF).

$LS(i,j) = LF(i) - t(i,j)$ (3)
$LF(i,j) = TL ; TL = TE$ (4)

ES : The fastest start of activity TE : The fastest event
EF : The fastest completion of activity t : Time required for an activity

Finding the total float and free float is the next step in determining the critical route. Total float (5) is the maximum amount of time that allows activities to be completed later without slowing down the project's overall completion schedule. The project completion duration is determined by this phase, which is also the most important stage or longest implementation path. Calculate the total float of each project activity before establishing the critical path since the critical path has a total float of zero.

$TF = LF – ES – t$ (5)
$FF = EF – ES – t$ (6)

ES : The fastest start of activity TE : The fastest event
EF : The fastest completion of activity t : Time required for an activity

PERT, on the other hand, makes use of three different time estimates: Ta (Optimistic Duration Time), Tm (Most Likely Time), and Tb (Pessimistic Duration Time). By brainstorming with the ERP implementation team, three estimates of the time spent in PERT were produced. Therefore, we need to look for the average time value by using the formula (7):

$$Mean\ (Te) = \frac{To+4Tm+Tp}{6} \quad (7)$$

Then, establishing the PERT network's critical route. This is determined by the slack computation, which shows that the activity has free slack (FS) of value and total slack (TS) of zero. The next step is to determine the variance (8) and standard deviation (9) for each activity after the critical route has been identified.

$V = (Tp - To)/6$ (8)
$S = \sqrt{V}$ (9)

The probability of construction time completion is determined using deviation formula (10) in the calculation of settling time using the PERT technique.

$$Z = \frac{x - \sum Te\ critical}{3\sqrt{\sum Vcritical}} \quad (10)$$

3. RESULT & DISCUSSION

The research's techniques, CPM & PERT, which have two options, are included in the discussion and findings. Subsequently, the potential outcomes will be compared in the discussion section, and the research's ultimate findings will be discovered.

3.1. Result

The following outcomes of the identification of the Network Diagram of the dependence for Activity Option 1 are derived based on the activity dependence data for Option 1:

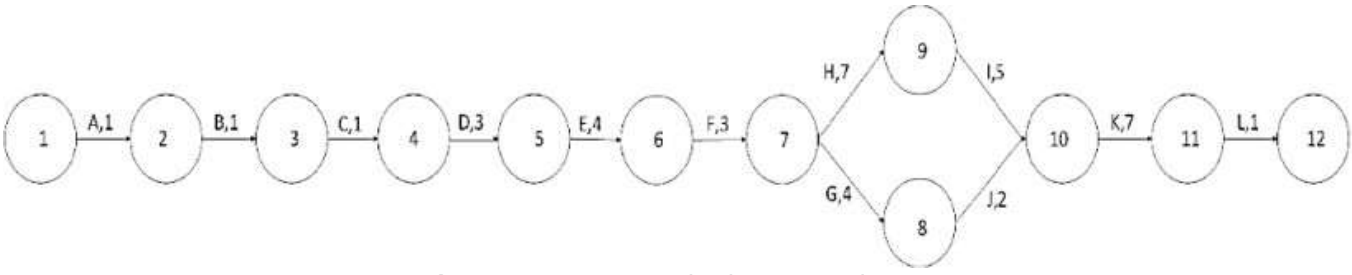

Figure 1. CPM Network Diagram Option 1.

Additionally, Free Float, Total Float, Forward Calculations, and Backward Analysis are collected and are compiled in a single table. Activities with a Total Float (TF) value of 0 are included in the critical route. Calculation results from the CPM method option 1 show that the project completion time is 33 days and the critical path which consists of various activities as a sign that the project activity is a critical path is marked yellow. The following is the Critical Path Network Diagram for CPM Method option 1:

The following outcomes of the identification of the Network Diagram of the dependence for Activity Option 2 are derived based on the activity dependence data for Option 2:

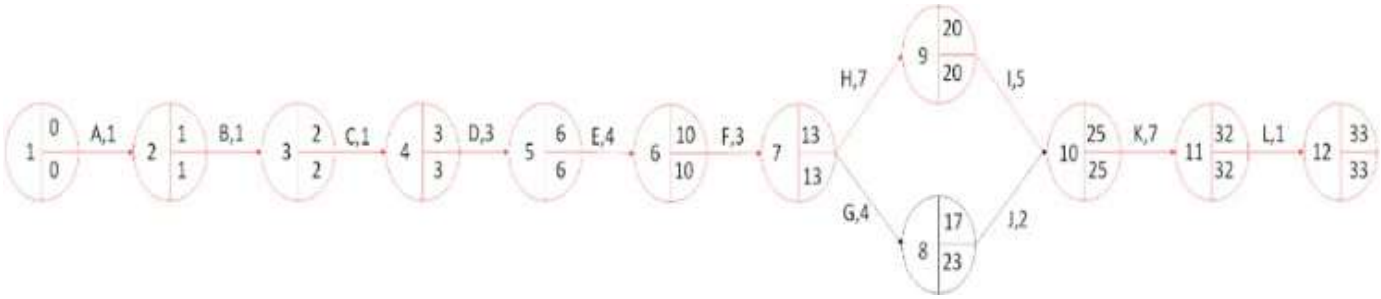

Figure 2. CPM Critical Path Option 1.

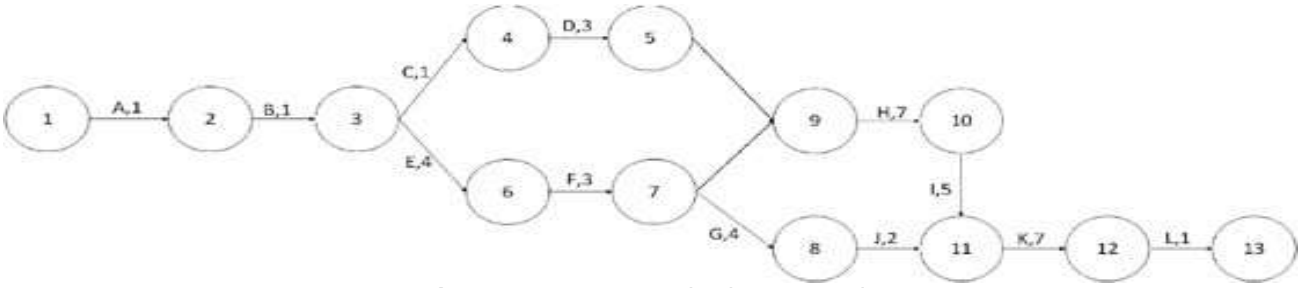

Figure 3. CPM Network Diagram Option 2.

Additionally, Free Float, Total Float, Forward Calculations, and Backward Analysis are collected and are compiled in a single table. Activities included in the critical path are activities that have a Total Float (TF) value = 0. According to calculation findings from CPM technique option 2, the project will be completed in 29 days, and the critical path will be made up of several CPM operations. A project activity is marked yellow to indicate that it is on the critical path. The Critical Path Network Diagram for CPM Method Option 2 is as follows:

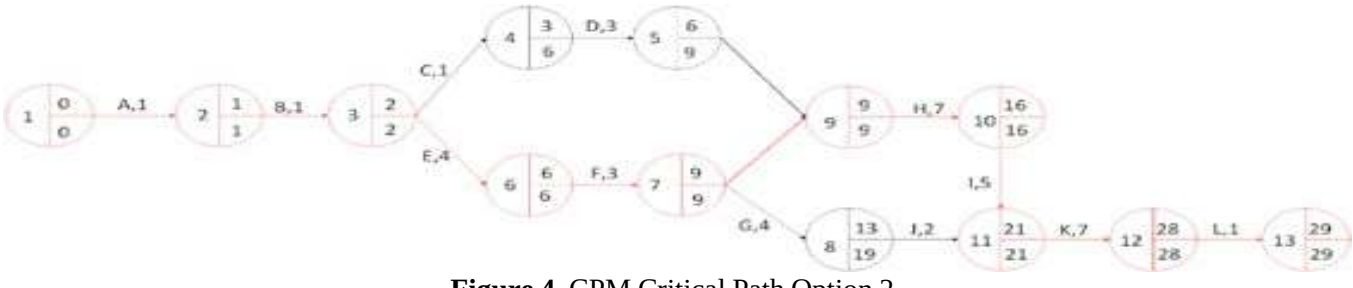

Figure 4. CPM Critical Path Option 2

In this study, PERT is either used to calculate the probability that a project will be successfully completed on schedule. Based on PERT option data processing, the calculation results for estimating the probabilities that a project will be completed using CPM scheduling method option 1 obtained a value of Z = 0.58. Because we wanted to find the probability in percent form, the Z value was converted into a percent with the aid of the standard normal probability table, yielding the result 0.7190 x 100 = 71.90%, which indicates the probability that a project will be successfully scheduled using CPM option 1 method. For the second option, the probability of success in scheduling a project using the CPM method opt 2 in PERT data processing option 2 obtained a value of Z = 0.64 schedule for the second option because the researcher intended to find the probability in percent form, the Z value was converted into a percent with the help of the standard normal probability table, with a result of 0.7389 x 100 = 73.89%.

3.2. Discussion

While the PERT approach is utilized in this research to examine the percentage chance of successful completion on time in project scheduling that employs the CPM method, the CPM method is used to identify work networks, identify essential activities, and improve project scheduling. The CPM and PERT methods were applied in this study in order to find the best outcomes (shortest project completion time and highest likelihood of successful project completion on time). Option 1 involved computing the CPM and PERT methods based on the sequence of activity dependencies according to the total capacity employees according to the actual project conditions, i.e. 3 people. Option 2 involves computing the CPM and PERT techniques based on the dependence order of the activities based on the projected capacity of the number of employees of 5. The following table shows a comparison of the durations for finishing an ERP implementation project utilizing the two CPM and PERT technique options:

Table 1. Comparison of PERT CPM Duration Option 1 and 2.

CPM/PERT Opt 1 (day)	CPM/PERT Opt 2 (day)	Deviation (day)
33	29	4

The proportion of projects that are successfully completed on schedule while employing the two CPM and PERT approach alternatives is contrasted as follows:

Table 2. Comparison of PERT CPM Percentage Option 1 and 2.

CPM/PERT Opt 1 (%)	CPM/PERT Opt 2 (%)	Deviation (%)
71.90%	73.89%	1.99%

From the comparison of the project completion times, it is obvious that option 1 takes longer to complete than option 2. based on an examination of the outcomes of the work network diagrams for options 1 and 2, respectively. There are four actions that may be done at once in the work network of option 1. as opposed to option 2, which allows for the simultaneous execution of six actions. This demonstrates that the time of an activity decreases with the number of concurrently carried out tasks, hence option 2 has a lower duration than option 1.

Meanwhile, from the percentage of success for choice 1 is lower than option 2, it can be inferred from the comparison statistics on the success rate of completing projects on schedule. This is so because option 1 contains 10 crucial tasks, but option 2 only has 8 crucial tasks. This demonstrates that the proportion of success will drop as the number of important activities increases since crucial tasks are those that cannot be completed late. The entire project may incur delays if one of the crucial tasks is delayed. This implies that there is a larger chance of project delays the more crucial activities there are in the project timetable.

4. CONCLUSION

A potent strategy to effectively plan, manage, and carry out complicated ERP deployments is to combine an ERP (Enterprise Resource Planning) project with the CPM (Critical Path Method) and PERT (Program Evaluation and Review Technique) techniques. By incorporating CPM and PERT approaches into your ERP project, you may better manage project schedules, resources, and risks, improving the likelihood of a successful deployment. These techniques offer organized ways to project planning, monitoring, and management, making sure that your ERP system is in line with your corporate goals and provides the anticipated results. The following findings are drawn from the PERT CPM scheduling that was done for the SME's CERP implementation project:

- Based on the results of identifying the work network in project scheduling for options 1 and 2, it was discovered that option 1 has fewer simultaneous activities than option 2. Option 1 can only be used for 4 simultaneous activities, whereas option 2 can be used for 6 simultaneous activities. The reason why option 1 requires more time to complete the project than option 2 is due to the difference in the number of simultaneous activities that may be performed.
- Project scheduling option 1 has more critical activities than project scheduling option 2, according to the findings of utilizing the CPM technique to determine the critical route in these two alternatives for scheduling projects. Option 1 for project scheduling contains 10 key activities, but option 2 only has 8 critical

activities. The entire project will incur delays if one of the tasks is delayed. This implies that the likelihood of project delays will rise as the number of crucial activities in the project schedule increases.

- According to the outcomes of project scheduling that has been improved using the CPM approach, alternatives 1 and 2 have shorter project completion times than current project scheduling, which calls for a completion time of 39 days. Project scheduling option 1 takes 33 days to complete, however project scheduling option 2 takes just 29 days.
- The probability of completing the CPM option 1 method project scheduling on time was found to be 71.90%, while the probability of completing the CPM option 2 method project scheduling on time was found to be 73.89%. These findings are based on the analysis of the probability of project completion on time using the PERT method in CPM option 1 and option 2 project scheduling.

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Cite this Article: Lufti, MI; Haekal, J; Mu'min, R; Darlion, FL (2025). Project Evaluation for Digitalization of Manufacturing Process Using Combination of PERT and CPM Approach in Snell X Cloud Enterprise Resource Planning Company. *Greener Journal of Environmental Management and Public Safety*, 13(1): 188-193, https://doi.org/10.15580/gjemps.2025.1.032725066.