PROJECT DELIVERY TIME - MONTE CARLO SIMULATION

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Background :

I worked as a manufacturing engineer. Our company bids for projects and estimates the cost of the bid to the company based on the historical project completion time and no. of work items to be completed. Since this historical data is sourced from a no. of teams in the company and over 10 years. Ideally , the project completion time should be calculated including only the information of the recent performance of the team which it is going to be allotted to. But, the paradox is , we wont have enough data to base the estimation on one team's performance. So, company doesn't have any option but to include the historical data of all the projects done by the company to arrive at an estimation. This leads to frequent over or under estimation.

One of the primary learning through the course has been to overcome the weakness of not having enough data , specially through resampling methods like monte carlo simulation.

Goal :

Through this project I will try to estimate the delivery time of a project and in turn cost to the company based on just the sample performance of the team it is going to be allotted to. Rather than using the entire company's data for large sample size, I will use resampling of the team's sample data and predict the delivery time specific to that team.

Data source :

Internal data from Reliance Industries Limited (Previous Employer)

Description :

In this analysis, each project is defined as a set of work items each one representing independent customer value that must be delivered on or before due date.

Because of the nature of work items specific to our company, each work item is more or less of the same size. So, in this analysis each work item's workload is assumed reasonably similar.

Metrics used :

Avg Takt time = Time period over which the project will be delivered/ Number of work items to be delivered in that period.

If,

N = No. of work items per project

T = Total project delivery time period

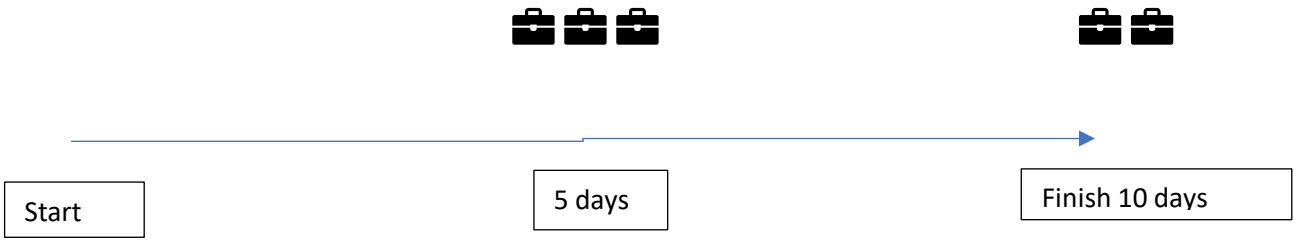
TT_{avg} = Average Takt time

- $TT_{avg} = T/N$

Example : For a project overall project delivery time = 50 days and no. of work items is 50, average takt time is 50/50 = 1 day.

Example :

In this analysis , takt time is measured in days and anytime less than a day is considered 0 days.



Here Takt time for the first work item delivered after 5 days is 5 days, the takt time of the second and third task completed at the end of 5 days is 0 days, because the time between the first and second work item is less than a day.

Work item number	Takt time(TT)
1	5
2	0
3	0
4	5
5	0

Here you can notice that the sum of takt times of all work items = project delivery time

- $T = N* TT_{avg}$

In this analysis, we used monte carlo simulation to generate average takt time distribution

This distribution is unique to each team and cannot be used if the inner workings of any team are changed. Anything in the team eg. The employees, working method etc, the distribution has to be regenerated.

General algorithm used to predict delivery data :

1. Collect sample takt time data of the team.
2. Calculate the distribution of Avg takt time using Monte Carlo simulation
3. Generate delivery time probability distribution based on the average takt time distribution using monte carlo simulation
4. Use the probability distribution for estimating the delivery time.

Project Flow :

Here sample project is taken as an example

Project start	**1/1/2018**		
Done date	**Count of done**	**Takt Time**	**In Parallel**
05.01.2018 r.	1	4	0
12.01.2018 r.	1	7	0
15.01.2018 r.	3	3	2
17.01.2018 r.	2	2	1
18.01.2018 r.	3	1	2
20.01.2018 r.	5	2	4
24.01.2018 r.	1	4	0
26.01.2018 r.	2	2	1
30.01.2018 r.	4	4	3
01.02.2018 r.	1	2	0
02.02.2018 r.	2	1	1
05.02.2018 r.	1	3	0
08.02.2018 r.	1	3	0
13.02.2018 r.	2	5	1
18.02.2018 r.	1	5	0
Total	**30**		**15**

Figure 1

“Count of done” is populated with the no. of work items delivered at a particular date.

For instance on January 17 2018 , 2 work items have been delivered and the next day 3 work items have been delivered. After calculating takt times , we calculate the no. of work items completed in parallel. That is calculated in the column “In Parallel”. Work items delivered in parallel , will have takt time of zero days.

For Eg, 3 work items are delivered on 15th January, 1 will have takt time of 3 days and the other 2 are work items in parallel and have takt time of 0 days.

Then , I created a pivot table showing the distribution of takt time of the sample data.

Takt Time	Count of Takt Time
1	2
2	4
3	3
4	3
5	2
7	1

Figure 2

Takt Time	Work Items	Project Length
0	15	0
1	2	2
2	4	8
3	3	9
4	3	12
5	2	10
7	1	7
15	**30**	**48**

Figure 3

- Figure 3 is an extension of the above pivot table which also includes the takt times of works in parallel.
- Project length = sum(takt time x work items) = 48

Project length	43
Avg TH	0.697674419
Avg 1/TH	1.433333333
Avg TT	1.433333333

Monte Carlo Simultion for Avg takt time :

Populating historical takt time values by indexing each work item with one of the sample takt time values. Resampling of this sample is done . Resampling column is filled by choosing the values in takt time column at random..

	Takt Time (days/work item)	Resampling
1	0	0
2	0	3
3	0	3
4	0	0
5	0	4
6	0	4
7	0	3
8	0	1
9	0	0
10	0	0
11	0	0
12	0	7
13	0	1
14	0	2
15	0	0
16	4	0
17	7	3
18	3	1
19	2	3
20	1	0
21	1	0
22	5	0
23	2	4
24	4	0
25	2	0
26	1	0
27	3	1
28	3	1
29	1	2
30	4	0

Below is the head of the values of total delivery time generated by summing up all the values of the resampling column of the previous figure for calculating each entry in the delivery time column.1000 values for delivery time are being generated.

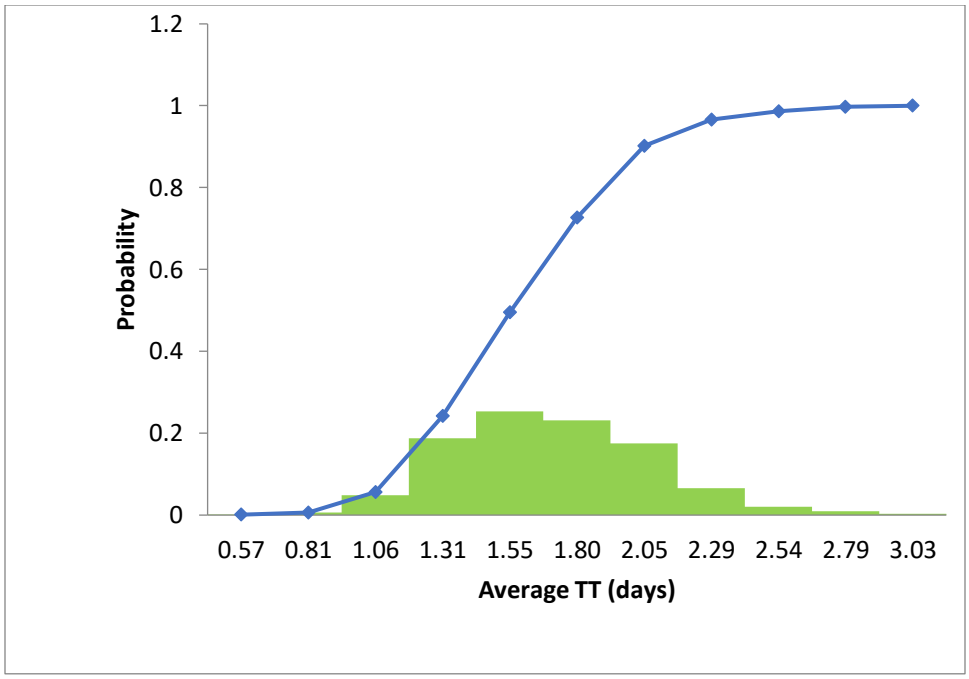
#	Delivery time (T)	Average Takt Time (TT)
	43	
1	43	1.433333333
2	29	0.966666667
3	57	1.9
4	29	0.966666667
5	57	1.9
6	57	1.9

For each delivery time entry an Avg Takt Time entry is populated by divinding it with no. of work items in the sample project

Probability distribution of Avg . Takt time is being plotted.

Now we use this avg tkt time distribution to find delivery time distribution when we have the information on work items.

Delivery Time = Avg Takt Time x No. of work items



Result :

Projected Delivery time for N work items :

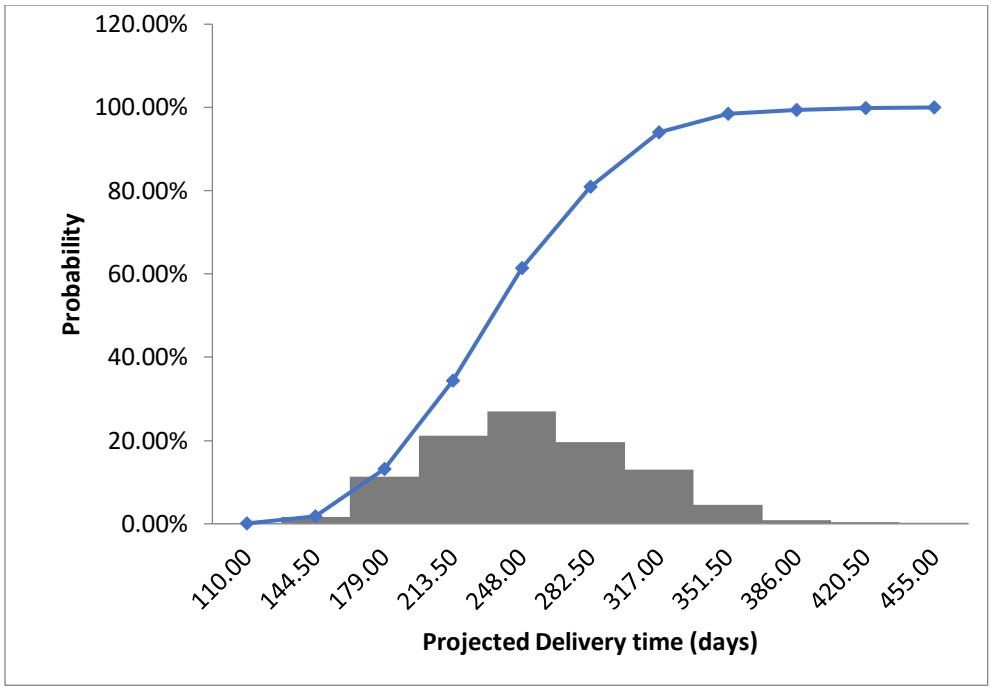
Now that we have average takt time distribution, we can derive the distribution of delivery time of a project with N work items.

Since Project Delivery Time (T) = N x TT_{avg}

We get the Delivery time distribution :

For Example , for N = 150 , the delivery time is 330 days. We can take the delivery time with 95 % certainty as the prediction for the delivery time.

Project scope (work items)	Delivery time with 95% certainty (days)
150	330



Through this project estimated the delivery time of a project based on just the sample performance of the team it is going to be allotted to. Rather than using the entire company's data for large sample size, I used resampling of the team's sample data and predict the delivery time specific to that team.