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Overall Schedule Risk Simulation (OSRS) rather than Risk Expected Value Simulation (REVS) for Schedule Risk Analysis [1]

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1. Abstract

Considering the variety of situations and factors that project practitioners encounter, finding a suitable method to determine schedule contingency is always a challenge for project risk analysts. Factors such as the level of available information, maturity of the scope of work, available software, and technical expertise all influence the choice of analysis method. In situations where there is a lack of manpower or a reliable detailed schedule, one method currently in use is Expected Value analysis with Monte Carlo simulation, referred to here as Risk Expected Value Simulation (REVS). This paper describes the REVS method, assesses its pros and cons, and evaluates its validity. Following this, another method is introduced: Overall Schedule Risk Simulation (OSRS), which involves running Monte Carlo simulations with schedule simulation software.

2. Introduction

It might be considered a rule in our world that nothing is certain. The question is not whether uncertainty exists, but to what extent. This rule is especially relevant in the world of projects. Estimating something like duration in a project, which is a temporary and unique event, inherently involves a high level of uncertainty. All assumptions in a project are uncertain. One key aspect that needs to be controlled in a project is its duration. Project schedulers typically report a deterministic date for every project activity, particularly the main milestones. Given the uncertain nature of these estimations, it is logical to ask the following questions:

- How confident are we in the reported dates?
- What is the likelihood of meeting the reported date?
- How much time should be considered as a contingency reserve?

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Schedule risk analysis is a common approach used by project practitioners to address such questions. To conduct a reasonable and reliable risk analysis, the project risk analyst needs to find a suitable method. Several methods have been introduced for performing schedule risk analysis, one of which is Risk Expected Value Simulation (REVS).

While REVS is recommended as one of the primary methods for conducting schedule risk analysis that considers project-specific risks, it has some drawbacks. This article initially introduces the REVS method, explores its primary limitations, and subsequently introduces the Overall Schedule Risk Simulation (OSRS) method. The OSRS method mitigates some of the shortcomings of REVS and can serve as a viable alternative.

3. Risk Expected Value Simulation (REVS)

3.1. Introduction

This method uses the statistical concept of Expected Value to calculate the impact of individual risks and employs Monte Carlo simulation to create the duration probabilistic distribution.

The concept of expected value has long been used to analyze probabilistic situations by multiplying the probability of events by their impact. This same concept is applied in project risk management to calculate the impact of risks as follows:

*Expected Value of a risk = Probability of Occurrence * Impact of risk*

For example, if a risk has a likelihood of 40% and a schedule impact of 100 days, its expected value will be 40 days, calculated by multiplying 40% by 100 days.

3.2. Method

REVS method is comprised of 4 steps as follows:

1- Define the total duration needed to meet the target milestone.
2- Identify risks with their probability of occurrence and impact.
   Note: Impact of risks is defined as a distribution function. For example, Triangle, Trigon, Betapert, Uniform, and the like.
3- Adjust the formula of Probability * Impact for each risk. Then sum up the duration of target milestone with the impact of all risks to determine the total duration, taking the risks into account.
4- Run simulation with thousands of iterations (for example, 5000) using the formula for risk impact.

Note: In this step, the simulation process takes a value by considering the defined distribution function for the impact of each risk and multiplies it by the probability of that risk.

By running aforementioned four steps, the probabilistic distribution of target milestone duration is generated by simulation software.

3.3. Example:

Assume there is a project with duration of 800 days. Five risks have been identified as specified below:

Risk	Likelihood	Impact
Risk 01	50%	Betapert (60, 80, 100)
Risk 02	40%	Betapert (50, 60, 100)
Risk 03	40%	Betapert (100, 120, 150)
Risk 04	60%	Betapert (80, 90, 120)
Risk 05	80%	Betapert (40, 80, 120)

In REVS method, the total duration of project by considering the impact of all risks, is calculated as follows:

800 + (50% * Betapert (60, 80, 100)) + (40% * Betapert (50, 60, 100)) + (40% * Betapert (100, 120, 150)) + (60% * (Betapert (80, 90, 120)) + 80% * (Betapert (40, 80, 120))

By running the Monte Carlo simulation, in every iteration, a number is taken from each duration distribution and the final result will be as follows:

Confidence Level	P0	P10	P20	P30	P40	P50	P60	P70	P80	P90	P100
Duration	989	1,016	1,022	1,027	1,031	1,035	1,039	1,043	1,048	1,054	1,081

And the mean duration is 1035 days.

3.4. Discussion:

The main characteristic expected from any model is its alignment with the real situation being analyzed by the model. Comparing what this model does with what is happening in real situations, two points are raised:

First Point

In reality, any risk may or may not happen. For example, if Risk 01 occurs, its impact will be between 60 and 100 days, and if it doesn't occur, its impact will be zero. However, in this method, the applied impact for this risk is calculated by multiplying its probability by its impact, resulting in a range of 30 to 50 days. This 30 to 50 days impact never actually happens in reality. This issue causes a compressed range of results. While the mean value is reasonable, the higher and lower limits of the resulting duration distribution (989 and 1081) are not accurate.

To understand this problem, needs to delve into the concept of expected value. In probability theory, the expected value is used to determine the mean of possible values of a random variable. Thus, it is not applicable for a single outcome but represents the average value of multiple outcomes.

Second Point

Another point that can be highlighted as misalignment of this method with reality is the number of risks considered in the calculations. In the REVS method, the impacts of all risks are aggregated together, while in reality, the chance of all risks occurring together is very low. For example, in the example provided earlier, the chance of all risks occurring simultaneously is only 3.8%.

Third Point

One of the primary inputs of this method is the impact of risks on the project schedule. Since the schedule precedence network is not utilized in this method, accurately calculating the impact of risks, considering the critical path of the schedule, may not be feasible.

Mitigation for First and Second Point

A beneficial aspect of REVS is the reversal of the two issues described earlier. Firstly, it reduces the impact of risks by multiplying them by their probability. Secondly, it -in reverse- amplifies the impacts of risks by aggregating them together. This reversal of issues is only beneficial when the number of risks is not very low. An empirical assessment indicates that the optimal number of risks to achieve a reliable result may be above 10.

Having said that, in all cases, the REVS method yields a reasonable mean value. The aforementioned issues become applicable when we require the probabilistic range of confidence levels, such as results with confidence levels below 30% and above 70%.

However, while the two issues described earlier are mostly resolved when the number of risks is above 10, there still remains a level of bias in the results- even if it is acceptable. Therefore, developing a method that operates with the same inputs required in REVS could be beneficial.

4. Overall Schedule Risk Simulation (OSRS)

4.1. Method

OSRS can be run by considering the overall duration to meet the target milestone, along with the risks, their likelihood, and the duration distribution of their impact. The steps in the OSRS method are as follows:

1- Define the total duration of target milestone.
2- Identify risks with their probability of occurrence and impact.
   Note: Impact of risks is defined as a distribution function. For example, Triangle, Trigon, Betapert, Uniform, and the like.
3- Add an activity with duration of target milestone in a schedule risk analysis software.
4- Add risk with their likelihood and duration distribution of their impact in the schedule risk analysis software.
5- Run Monte Carlo simulation.

For instance, running OSRS for the same example used earlier, the results are as follows:

Confidence Level	P0	P10	P20	P30	P40	P50	P60	P70	P80	P90	P100
Duration	800	897	954	978	1,007	1,036	1,058	1,085	1,122	1,165	1,306

And the mean duration is 1035 days.

4.2. Discussion

Comparing the results of OSRS with those of REVS validates following points mentioned earlier:

- With a low number of risks (in this example, 5 risks), the range of the resulting duration distribution is not wide enough.
- The mean value in both methods is equal.

Below is a table showing the differences in results:

Confidence Level	P0	P10	P20	P30	P40	P50	P60	P70	P80	P90	P100
Result from OSRS	800	897	954	978	1,007	1,036	1,058	1,085	1,122	1,165	1,306
Result from REVS	989	1,016	1,022	1,027	1,031	1,035	1,039	1,043	1,048	1,054	1,081
Difference %	24%	13%	7%	5%	2%	0%	2%	4%	7%	10%	17%

As mentioned earlier, by having a reasonable number of risks, the biases in the results of REVS method are considerably mitigated. The following example can validate this assertion and demonstrate how the number of risks affects the accuracy of results.

Assume having a project with 600 days with 7 different number of risks as follows:

Case 1: 5 risks with probability of 50% and duration distribution impact of Uniform (0,240)

Case 2: 10 risks with probability of 50% and duration distribution impact of Uniform (0,120)

Case 3: 20 risks with probability of 50% and duration distribution impact of Uniform (0,60)

Case 4: 30 risks with probability of 50% and duration distribution impact of Uniform (0,40)

Case 5: 40 risks with probability of 50% and duration distribution impact of Uniform (0,30)

Case 6: 60 risks with probability of 50% and duration distribution impact of Uniform (0,20)

Case 7: 80 risks with probability of 50% and duration distribution impact of Uniform (0,15)

Running analysis with both REVS and OSRS method, the result is as follows:

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Case No	Confidence Level	P0	P10	P20	P30	P40	P50	P60	P70	P80	P90	P100
Case 1	Result from OSRS	600	676	746	800	840	890	935	989	1,049	1,144	1,556
	Result from REVS	650	800	833	859	880	900	920	944	971	1,004	1,166
	Difference %	8%	18%	12%	7%	5%	1%	2%	5%	7%	12%	25%
Case 2	Result from OSRS	600	743	793	829	861	894	927	961	1,004	1,064	1,331
	Result from REVS	712	827	853	870	885	900	915	929	949	971	1,074
	Difference %	19%	11%	8%	5%	3%	1%	1%	3%	5%	9%	19%
Case 3	Result from OSRS	636	789	824	851	874	897	920	945	973	1,013	1,238
	Result from REVS	749	847	866	878	889	899	909	921	934	952	1,038
	Difference %	18%	7%	5%	3%	2%	0%	1%	3%	4%	6%	16%
Case 4	Result from OSRS	644	809	838	860	880	899	916	936	960	993	1,143
	Result from REVS	787	857	871	882	891	901	909	917	929	943	1,037
	Difference %	22%	6%	4%	3%	1%	0%	1%	2%	3%	5%	9%
Case 5	Result from OSRS	642	820	847	866	883	899	915	932	953	981	1,154
	Result from REVS	794	862	875	884	892	899	907	914	924	938	1,014
	Difference %	24%	5%	3%	2%	1%	0%	1%	2%	3%	4%	12%
Case 6	Result from OSRS	728	834	857	873	887	900	913	926	942	966	1,078
	Result from REVS	794	869	879	887	893	900	906	913	920	931	993
	Difference %	9%	4%	3%	2%	1%	0%	1%	1%	2%	4%	8%
Case 7	Result from OSRS	745	841	861	875	888	899	911	923	938	959	1,068
	Result from REVS	841	891	901	908	914	919	925	932	939	949	997
	Difference %	13%	6%	5%	4%	3%	2%	2%	1%	0%	1%	7%

As the above table shows, by increasing the number of risks, the results get closer.

5. Conclusion

1- Comparing the alignment of models with reality, as described in the First Point and Second Point under the REVS method, the process of the OSRS method is more aligned with reality.
2- Even though the REVS method's behavior is not exactly aligned with reality, the reversal impact of Points 1 and 2 described under the REVS method mitigates this problem, but only when the number of risks is not very low. Empirically, by a rule of thumb, the number of risks should be above 10.
3- To run the REVS method, you need software to perform Monte Carlo simulations in Excel. To run the OSRS method, you need schedule simulation software.
4- Both methods need similar inputs.

5- To run the REVS method, you need to develop a customized file in spreadsheet software like Excel. In contrast, the OSRS method can be easily run by defining an activity with risks in schedule risk analysis software.
6- Though the problem of not considering the exact schedule impact of risks due to the lack of a precedence network is common to both methods, the OSRS method, being run in schedule simulation software, allows for the possibility of developing a very overall schedule.

6. Final Suggestion

Considering the aforementioned points, in case of having a schedule risk analysis software, OSRS method looks more reasonable because:

- It is more aligned with reality, so the result are more reliable.
- It is easier.
- It provides the potential to develop a comprehensive precedence network, thereby increasing the accuracy of the risk schedule impact.

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About the Author

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Rasoul Abdolmohammadi, a Principal Engineer specializing in Planning & Scheduling at PETRONAS, brings over two decades of invaluable experience in project management. His expertise encompasses various domains, including time, cost, and risk management, establishing him as a distinguished figure in the industry. Rasoul has successfully developed, implemented, and executed project planning, control, and risk management processes across a wide range of international mega-projects within the oil & gas, utilities, and construction sectors.

Throughout his career, Rasoul has held pivotal roles such as Project Control Manager and Project Risk Manager, showcasing his proficiency in crafting pragmatic systems for project schedule, cost, and risk management. He is renowned for his innovative approaches to project risk analysis, a testament to his deep knowledge and insights in the field.

Rasoul's contributions extend beyond the workplace; he is the author of the acclaimed book, "Practical Project Risk Management Process," which encapsulates his wealth of experience and expertise. Furthermore, he actively shares his knowledge by presenting on project management best practices at prestigious international conferences, thereby enriching the collective understanding of project management methodologies

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