Unknown Unknowns in Project Probabilistic Cost and Schedule Risk Models

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Abstract

Practitioners recognise a requirement to consider unknown unknowns in project risk management. Same time, clear and consistent recommendations on incorporating of unknown unknowns into risk models have yet to be proposed.

This article outlines thinking process and comes up with practical recipes on handling unknown unknowns. Four dimensions of unknown unknowns are discussed: novelty of a project, phase of project development, type of industry and bias. A discussion on unknown unknowns vs. corporate risks is provided. Practical recommendations on including unknown unknowns into probabilistic cost and schedule risk models are put forward.

Key Words

Unknown Unknowns, Known Unknowns, General Uncertainties, Uncertain Events, Psychological Bias, Phase of Project Development, Monte Carlo Simulations, @RISK, Probabilistic Cost and Schedule Risk Analysis, Project Novelty, Corporate Risks, Project Contingency

1. Introduction

According to benchmarking data and definition of project failure by The IPA Institute, staggering 56% of major projects fail (*The IPA Institute, 2009*) due to

- budget overspending for more than 25%, and/ or
- schedule slipping for more than 25% , and/ or
- severe and continuing operational problems holding for at least one year.

One of the top reasons for the failures is inadequate or inconsistent application of proven project risk management methods. In other words, project scope, cost or schedule development cannot be considered completed or reliable until consistent project risk analysis is carried out. This requires development of adequate project contingencies.

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Following three groups of factors should be taken into account when building project's probabilistic cost and schedule risk models to evaluate the project contingencies (*Chapman and Ward, 2003*):

- Known Unknowns: general uncertainties ("ranges" around deterministic values of project baselines) and uncertain events (upside and downside risks) that were preliminary identified and quantified;
- Biases: conscious or subconscious systematic errors occurring when identifying and quantifying general uncertainties and uncertain events;
- Unknown Unknowns: factors that were missed by various reasons (including some types of organisational and psychological bias) when identifying general uncertainties and uncertain events.

By its nature dealing with unknown unknowns, not to mention their quantification, sounds mysterious. Same time, several publications point to importance of taking unknown unknowns into account in risk management (*Chapman and Ward, 2003; Hubbard, 2009; Wideman, 1992*). Missing or inadequately taken into account unknown unknowns lead to non-adequate contingencies. This certainly gives rise to the high project's failure rate mentioned above along with the other relevant factors.

Purpose of this article is to come up with consistent thinking process and recipes on handling unknown unknowns that may be used by practitioners. The approach outlined here was successfully used in Monte Carlo risk models of several major O&G projects related to pipelines, heavy oil, oil sands, conventional and unconventional gas, refineries, carbon capture & storage, etc.

2. Four Dimensions of Unknown Unknowns

Intuitively one may guess that the unknown unknowns should be higher for a unique project. It may employ a new technology or be planned in a new geography, or both. When both new technology and geography are involved, overall project risk exposure including unknown unknowns should be worst due to highest degree of novelty.

Obviously, a new technology may lead to some technical unknown unknowns. However, this might be a source of non-technical unknown risks too (*e.g.,* environmental and political risks).

Similarly, the new geography seems to lead to non-technical unknown unknowns related to political, organisational, commercial or economic risks. As a case in point, if two projects of a similar scope are planned in Western Canada and in Western Africa the latter may have more non-technical unknown unknowns than the former including country risks, etc. However, new geography may easily bring up technical unknown unknowns too (*e.g.,* subsurface risks).

Despite some industry lessons learned may be available, important is how they may be adopted and utilised by an organisation involved in a particular project. Any repetitiveness or standardisation of projects reduces unknown unknowns to a certain level as some of them should have already occurred and taken into account as known unknowns when planning new similar project. Eventually, a particular type of project employing a proven technology and repeated several times in a given geography may be considered standard.

Another dimension relates to a phase of a project development. When a project is in earlier phases of development (Identify or Select), it is reasonable to expect that unknown unknowns should have bigger room for existence. In the course of the project development this room is supposed to shrink as some of them may have already occurred.

In addition, type of industry or even projects inside industry (e.g., coal vs. unconventional gas production or onshore vs. offshore oil production, high-tech vs. pharmaceuticals, space exploration vs. railway transportation, etc.) may provide additional insights when considering project's unknown unknowns. This should shed light on general maturity of the industry and accumulated project experience in general.

There is fourth dimension that points to several types of bias. First and foremost, organisational bias that points to shortage of budget or time allocated to identification and quantification of risks, qualification of risk assessors, availability of well maintained corporate risk databases of historic risk data, information and methods used to develop baselines, involvement of third parties in project risk reviews, benchmarking, etc.

Besides the organisational bias, one cannot fully exclude some conscious bias factors such as "hidden agendas", when some risks might be "missed on purpose" to make a project more attractive, etc. This may be based on explainable desire to get project funding or support from key stakeholders. This could make some risks unknown.

At the end of the day, a fundamental question every organisation should keep in mind is: what is more preferable, to "unexpectedly" run into project failure or adequately and timely address as many failure factors as possible.

The bias factors certainly influence the level of development and quality of project risk registers. Same time, level of project development contributes itself to the quality of the project risk register. So, for the purpose of this paper we would tell bias and the phase of development apart.

Evaluation of unknown-unknown allowances is a combination of science and art. As discussed below, novelty and project development phase factors are easier quantifiable than bias and industry type factors.

3. Corporate Risks vs. Unknown Unknowns

Some risks (either known or unknown) may have catastrophic impact on project objectives usually having very low probability of occurrence. If occurred, they damage significantly or destroy project baselines. They are usually called "corporate risks". Some other terms used by practitioners are "game changers", "show stoppers", "black swans", etc. (The latter refers to a saying such as "It is about as likely as finding a black swan" (*Hubbard, 2009*).) Financial consequences of corporate risks are supposed to be borne not by a project but by an organisation at large. Certainly, they may be delegated to be managed at the project level through purchasing insurance, for instance.

Corporate risks, even if they are known unknowns, usually are not taken into account in project risk models as they drastically re-define project baselines. This outlines limits of probabilistic risk models through disclaiming that certain known "show stoppers" are not included in the probabilistic model. Good discussion about this is provided by *Chapman and Ward, 2003*. In essence, if corresponding contingency in the project budget estimated as a product of very low probability and very high impact, this would not be enough to cover the catastrophic event if occurred by a project team anyway. On the other hand, if the catastrophic event is not happening at all during the project lifecycle (which is very likely due to very low probability) this contingency becomes "free money" for the project. This is not efficient way of doing business, and the better method is corporate portfolio risk management.

Same approach is supposed to be taken when dealing with unknown unknowns. Namely, unknown-unknown allowances discussed below relate only to regular risks, not corporate risks. The issue with unknown-unknown corporate risks is that it is not possible to come up with an explicit disclaimer as in case of known unknown "show stoppers", as discussed above.

4. Developing Unknown-Unknown Allowances

As outlined in previous sections, following factors are to define the size of unknown-unknown allowances:

- Novelty of a project (mostly, technology and/ or geography);
- Stage of a project development and level of development of a project risk register;
- Type of industry;
- Bias of various types and quality of a project risk register.

Eventually only project teams can decide on size of the unknown-unknown allowances. Following guidelines and thinking process may be used by project teams to develop them.

Novelty has two key aspects – technology and geography. The guideline numbers of Table 1 for high and medium degrees of novelty should be understood as allowances when only one of aspects is relevant: either technology or geography. The worst case when both technology and geography are new should be given special consideration. From the angle of organisational strategy development, projects like that are rather unwelcome (*Grant, 1998*). In case both aspects of novelty are relevant, it should not be unreasonable to increase the unknown-unknown allowances, to say, by 30 – 70% or so.

In Tables 1 and 2 level of risk register development is associated with phase of project development explicitly. In other words, these Tables take into account only two dimensions of unknown unknowns out of four explicitly: novelty and project development phase. The third and fourth dimensions (industry type and bias) should be incorporated too by corresponding allowances fine-tuning. This represents quite complicated self-check which might not be free of bias itself. By this reason we don't come up with particular recommendations on the allowance's adjustments addressing type of industry and bias. However, it seems to be important to have particular guidelines on unknown-unknown allowances for various types of projects and industries. (Actually, the numbers of Tables 1 and 2 have certain relevance to O&G industry.)

Hence, allowances proposed in Tables 1 and 2 should not be taken literary and can serve only as initial guidelines illustrating the thinking process. The real allowances that would be used in risk models depend also on risk tolerance an organisation has and overall perception of risk register quality as well as on type of industry the organisation works in.

5. Corporate Scoring Contingency Development Procedures vs. Development of Unknown-Unknown Allowances

Some companies have proprietary scoring tools developed in-house that allow roughly evaluate project contingencies depending on project types and phase of development. Usually they are used at early project stages when project risk registers have yet to be developed. By that reason these tools based on standardised risk questionnaires may be considered as "forefathers" of project risk registers developed later. These tools are also used for a quick evaluation of contingencies in later phases playing a benchmarking role for probabilistic risk analyses.

These empirical scoring tools integrate three out of four unknown-unknown dimensions: project novelty (through scoring questionnaires) as well as phase of project development and project types inside given industry as additional factors. That is why it might be reasonable to link the corresponding contingency scores not only with contingency evaluation but with evaluation of unknown-unknown allowance used in probabilistic models. This may make corporate risk procedures self-consistent and streamlined. Corresponding calibration of scores vs. unknown-unknown allowances should not be more difficult than using Tables 1 and 2.

Table 1. Example of Unknown-Unknown Allowances When One of the Two Novelty Factors is Relevant

Novelty of a Project	*Phase of Project Development*			
	Identify	*Select*	*Define*	*Execute*
High Degree of Novelty	12%	9%	6%	3%
Medium Degree of Novelty	8%	6%	4%	2%
Standard Project	4%	3%	2%	1%

Table 2. Example of Unknown-Unknown Allowances When Either One or Two Novelty Factors are Relevant

Novelty of a Project	*Phase of Project Development*			
	Identify	*Select*	*Define*	*Execute*
High Degree of Novelty: Two Factors	18%	14%	9%	5%
High Degree of Novelty: One Factor	12%	9%	6%	3%
Medium Degree of Novelty: Two Factors	12%	9%	6%	3%
Medium Degree of Novelty: One Factor	8%	6%	4%	2%
Standard Project	4%	3%	2%	1%

6. Using Cost and Schedule Unknown-Unknown Allowances in Probabilistic Risk Models

Unknown-unknown allowances introduced above relate to both cost and schedule unknown-unknowns. However, they are applied differently as corresponding models are usually built in different software packages.

It is recommended to add a selected unknown-unknown cost allowance as a line into general uncertainties' ("ranges") model in @RISK or another Monte Carlo tool. Very broad range around this allowance is recommended, to say, +/-100% (triangular distribution). The minimal number -100% will correspond to a situation when unknown-unknowns don't occur. (As an alternative, this allowance may be put into project risk register with high probability. This adds another angle to consideration – probability – which seems to be unnecessary complication or overshooting due to the nature of the discussed topic.)

There might be reasons speculated to either correlate or anti-correlate this distribution with some or all ranges and/ or risks. To keep things simple and exclude overshooting, keeping the unknown-unknowns allowance distribution non-correlated at all should suffice.

In case of probabilistic schedule risk analysis the unknown-unknown allowance should be introduces as an additional normal activity at the very end of the project schedule. This allowance should correspond to percentage of the project duration. Again, very broad range around that additional activity duration (+/- 100%) may be considered. As an alternative, this allowance may be treated as an additional risk mapped to the project completion milestone. It may be reasonable to assign some probability to that risk in project risk register and schedule risk model. Very broad probability range (even 0 – 100%) may be considered. This approach reflects the difference between cost and schedule risk models as the latter is schedule-logic specific. The probability much less than 100% (to say, 50%?) reflects possibility that some unknown unknowns might occur out of critical path making minimal or no impact on the project completion date. Both alternatives may suffice due to very high level of uncertainty associated with unknown unknowns. The risk register alternative seems to be a bit more justifiable.

A question might be asked if a distribution should be used at all to introduce the allowance. It's sufficient enough to evaluate the allowance deterministically as a one-point-value addition to a probabilistic model. However, introduction of the allowance as a broad distribution should lead to broader overall cost or completion date distributions reflecting additionally the uncertainty associated with unknown unknowns.

7. Conclusions

It is not unusual to hear about some risks occurred during project development that were not part of project risk registers. Some although scarce historical data (all O&G industry related) were used to very roughly calibrate unknown-unknown allowances introduced by Tables 1 and 2. (This implies that the type of the industry was taken into account in Tables 1 and 2 in a way.) However, in every particular case this calibration should be challenged and revised by a project team. Hence, it would be interesting to evaluate and calibrate unknown unknowns for various project types and industries using collected historic data.

Due to high level of uncertainty associated with unknown unknowns this paper is not about precise unknown-unknown allowances but about corresponding thinking process. It is certainly better to do a right thing not exactly right, than ignore the topic whatsoever. Moreover, high precision in evaluation of unknown-unknown allowances is not possible or credible due to the nature of the subject. More important is managing unknown unknowns (at least partially) through addressing organisational and some other types of biases.

Several options of developing and using unknown-unknown allowances have been discussed above. Any company involved in projects of a sort may want to put forward a procedure that reflects its risk culture and line of business the best way. Guidelines and O&G examples introduced above provide enough ammunition for this. Then the procedure should be applied consistently across the project portfolio when developing project contingencies. Historic data on completed projects should be collected along the way. Along with managing bias, this might be a best method to treat unknown unknowns as right as practically possible.

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