Perspective on the Cost of Delayed Decision Making in Large Project Execution

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In this paper we will look at the cost impact of delay without a change in project scope or project rework. This condition is most closely associated with general delay as a result of:

- Extended decision making time frames by the project owner
- Project wide stop work orders from any of a variety of causes.

No loss of productivity from project disruption has been reflected except in the case considered at the end of this paper (Figure 13) where lost productivity from retrograde behavior of the site labor's learning curve or production curve is specifically considered. This differs from the so called "measured mile" approach often used in calculating disruption impacts.

In actual project situations the cause of delay is often associated with changed scope or rework and disruption and concomitant loss of productivity are real factors. The simplified analysis presented here is intended **to influence project decision making processes by better dimensioning the cost of delay** in establishing evaluation and decision making time frames. The cost of a lack of timely decision making is seldom reflected in project governance processes.

> ***"Ask of me anything but time"***
>
> \- ***Napoleon***

The analyses in this paper have been based on unconstrained labor, equipment and material factors which would act to further exacerbate the cost of delay. In general this analysis represents likely **minimum costs to be experienced by delay of a project**.

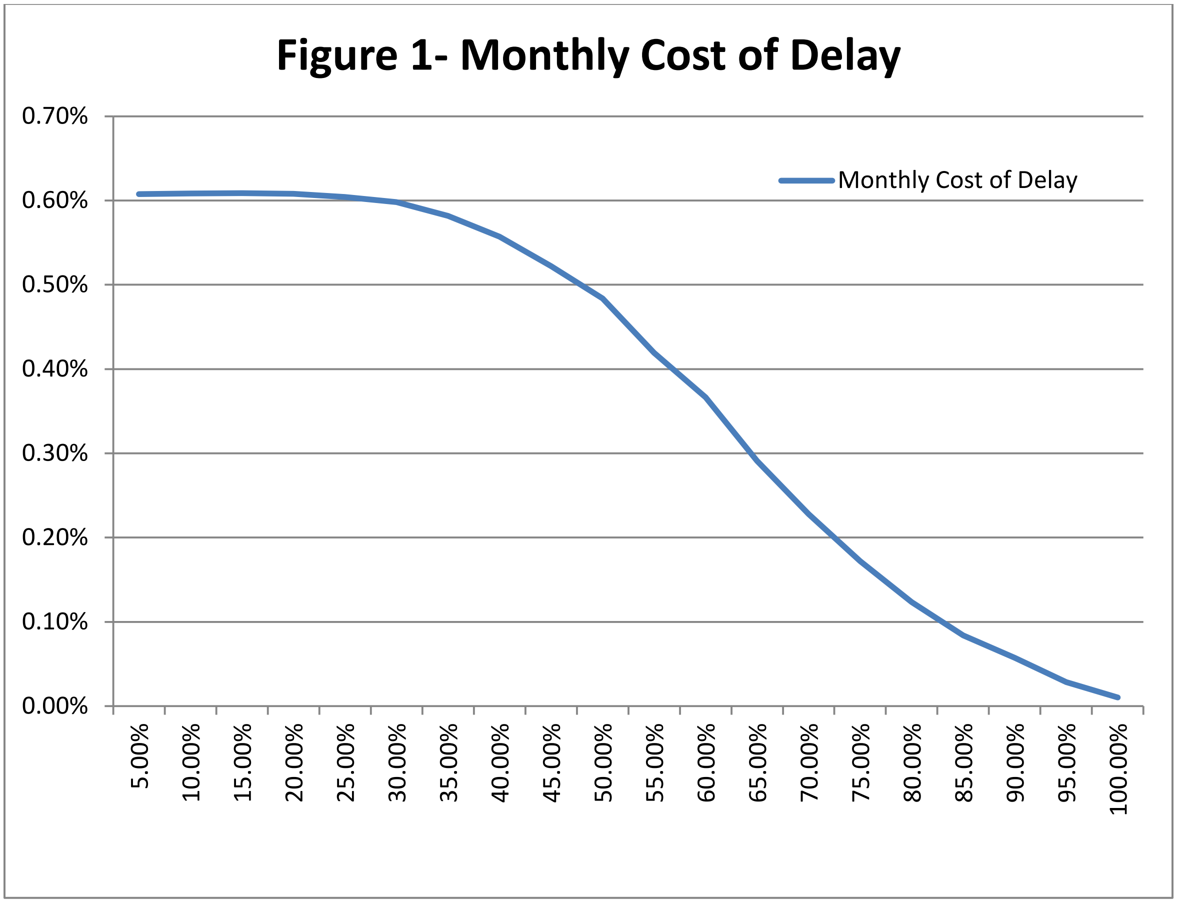


Figure 1 illustrates the monthly cost of delay, at the point in time such a delay occurs, normalized as a function of the project's initial estimate and duration. It considers the impacts of escalation and general condition costs, which persist during the delay period. In this example **escalation throughout the project period was assumed to be constant**. This would represent the **general contractor's view** on cost growth associated with delay, excluding any impacts from disruption including lost learning curve.

In evaluating the impact of delay, construction progress was assumed to follow a traditional "S"-curve, with no progress made during the delay period. General conditions cost were assumed to follow "S"-curve expenditure rates at a level equal to 10% of the expenditure rate. During the delay period general conditions costs were assumed to persist at the most recent monthly rate. Escalation was applied to uninstalled balances for simplicity in modeling.

Table 1 **Causes of Delay**
Timely decision making by owner
Changed owner performance requirements (fit for purpose redefined)
Intentional delay of project driven by business factors (market conditions; competing factors requiring management attention; cash flow or other financial market constraints)
Delayed or withheld regulatory approvals or changed regulatory requirements
Technical challenges not anticipated
Events anywhere in the supply chain broadly impacting progress

Figure 1 illustrates that the cost of delay, without disruption or loss of learning curve, is greatest at the initial stages of the project when the greatest balance to be escalated remains. The greatest impact actually comes at about 15% of original project duration as general conditions costs ramp up faster than the remaining value subject to escalation is reduced. The exact point in time is a function of the shape of the "S"-curve, assumed escalation rate and general conditions costs.

Figure 2 considers the case where escalation grows throughout the project period. **Overall costs are significantly greater (nearly 2X) and the peak cost is realized later** (25% of original project duration) than that associated with level escalation throughout the project period. As in Figure 1, the interplay between general conditions cost, "S"-curve progress and escalation on the uninstalled amounts can be seen. All other assumptions are consistent with the case illustrated in Figure 1.

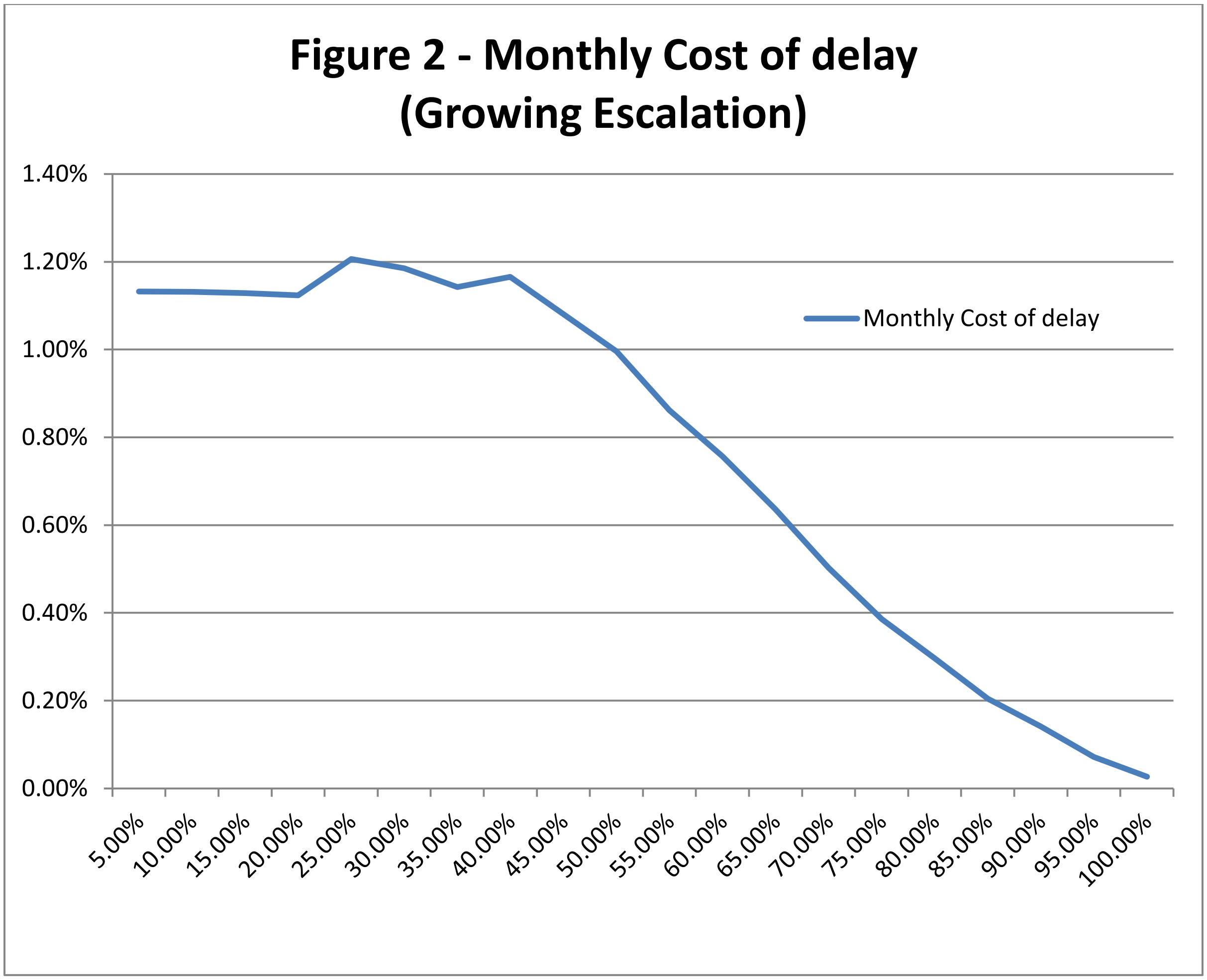
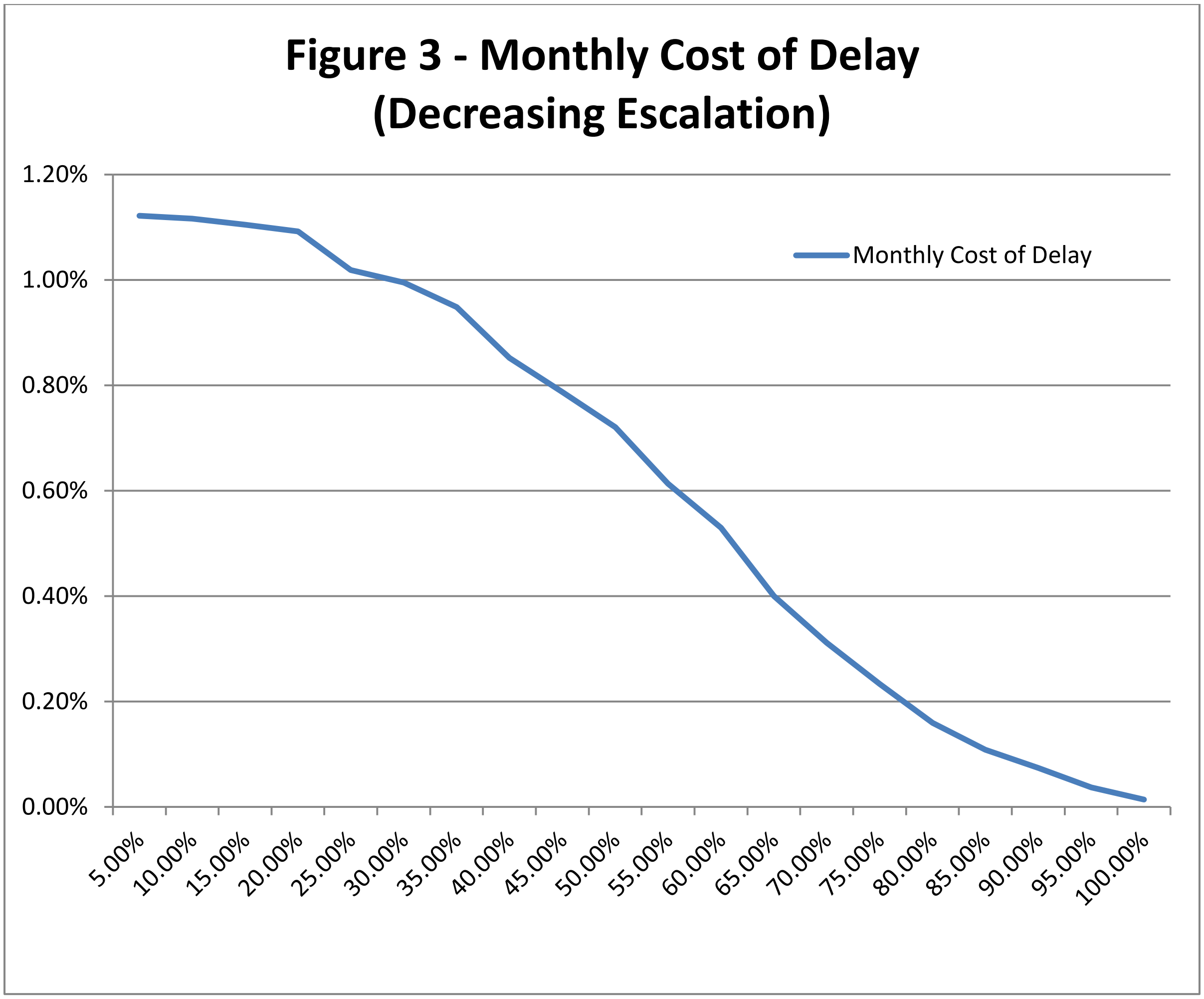


Figure 3 illustrates the impact of project delay as a function of when the delay occurs (% of original project schedule) for the case of declining escalation during the project period. In this example peak **delay cost is shifted to project initiation** in part due to the higher initial escalation rate used in this model (6% declining to 3.5%).



Each of these first three cases adopts a cost view akin to that seen by a general contractor. In reality though, owner's delay costs are much more and must include the weighted average cost of the capital they have committed to the project. These next three cases include the owner's cost of capital in assessing the total cost of project delay. All other assumptions are consistent with those associated with Figures 1 through 3. Owner's cost of capital is assumed to be applied to the installed project value and thus tracks the project's cumulative "S"-curve.

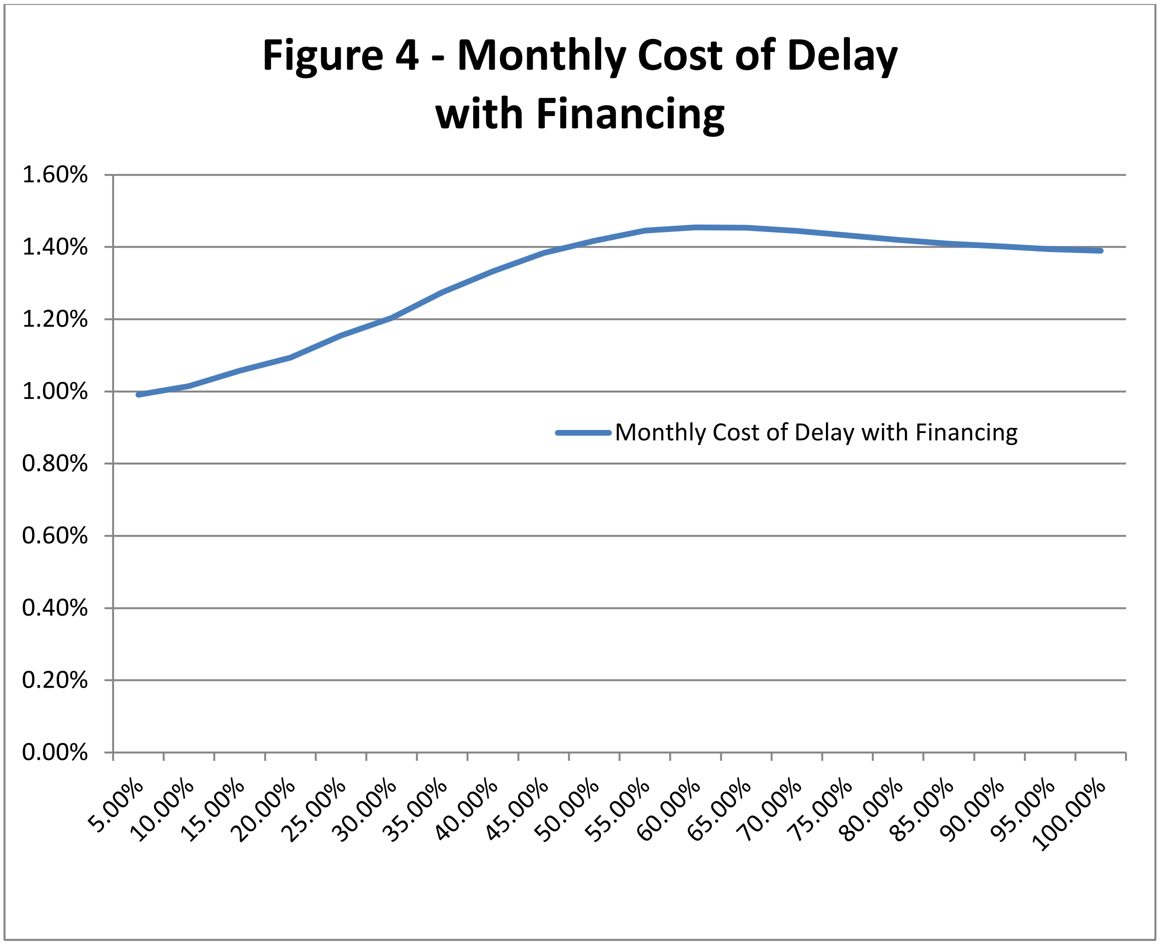


Figure 4 relooks at the cost of a month's delay as a function of when the delay occurs (as a % of original project schedule) but now including the owner's cost of finance. Escalation is level in this case at 3% annually (compounded monthly). The weighted average cost of capital (WACC) was based on a financing structure consisting of 15% equity and 85% debt with 15% and 8% annual cost, respectively.

Several significant changes relative to the case illustrated in Figure 1 are important to note:

- Overall cost of delay is significantly higher
- Peak delay cost shifts significantly in time to approximately 60% of the projects original schedule versus a peak at about 15% of the project's original schedule when financing costs are not included.
- Cost of delay essentially does not reduce over time, rather it rises to just after the midpoint of construction and remains at a high level as more installed project cost must be carried until project startup.

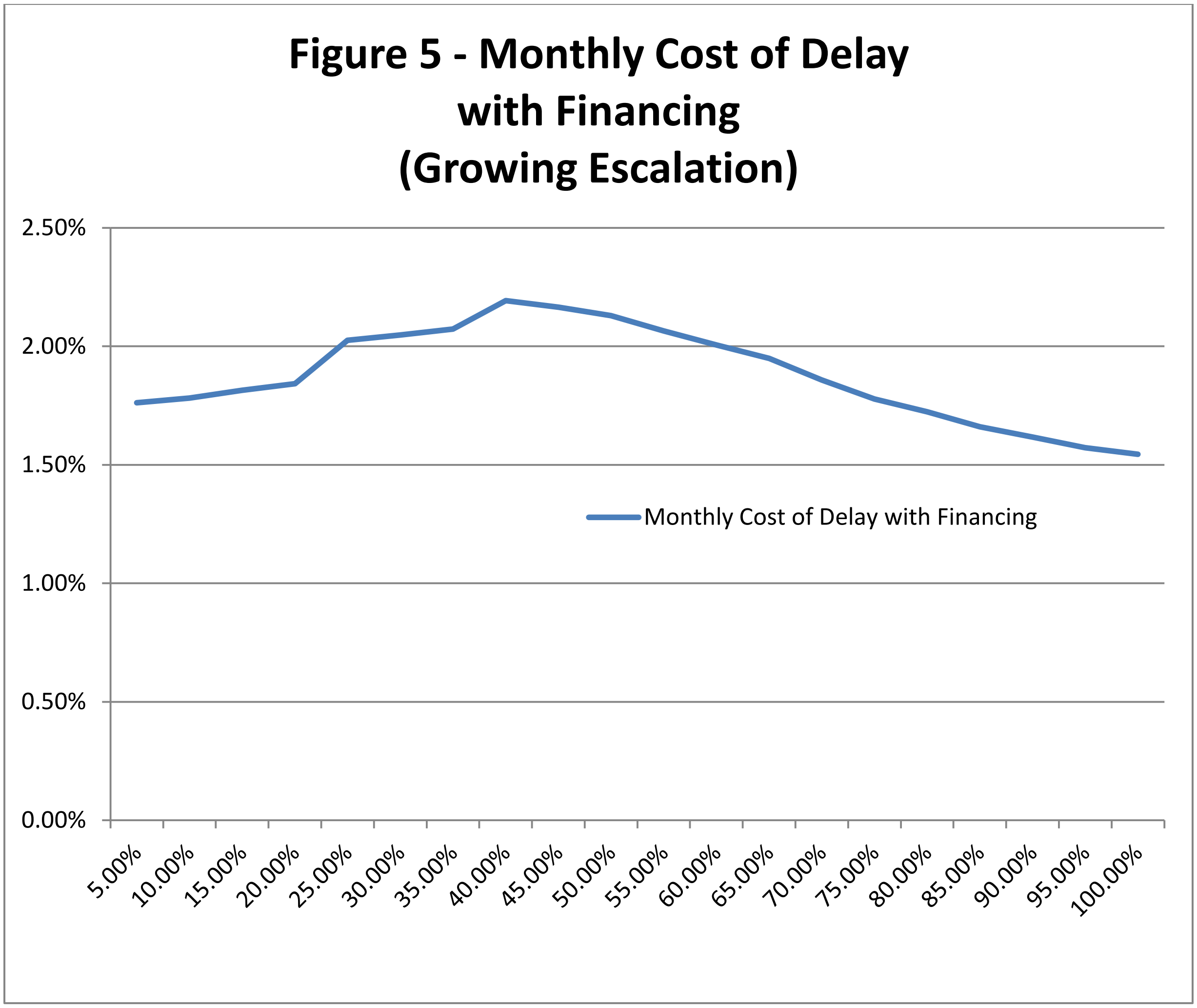


Figure 5 relooks at the case shown in Figure 2 with the owner's cost of financing included. The earlier in time that a delay occurs, the more the total project cost escalates versus an undelayed case. Peak monthly cost of delay is brought forward versus the levelized escalation example shown in Figure 4 (40% of original project schedule versus 60%) but still later than that seen in Figure 2 (25% of original project schedule) where financing costs were excluded. While we do see some drop-off in project delay cost over time it is not as significant as that reflected in Figure 2.

In this example we can also see the impact of overall higher project escalation versus Figure 4 with peak values reaching 2.19% versus 1.45% of original project cost per month of delay.

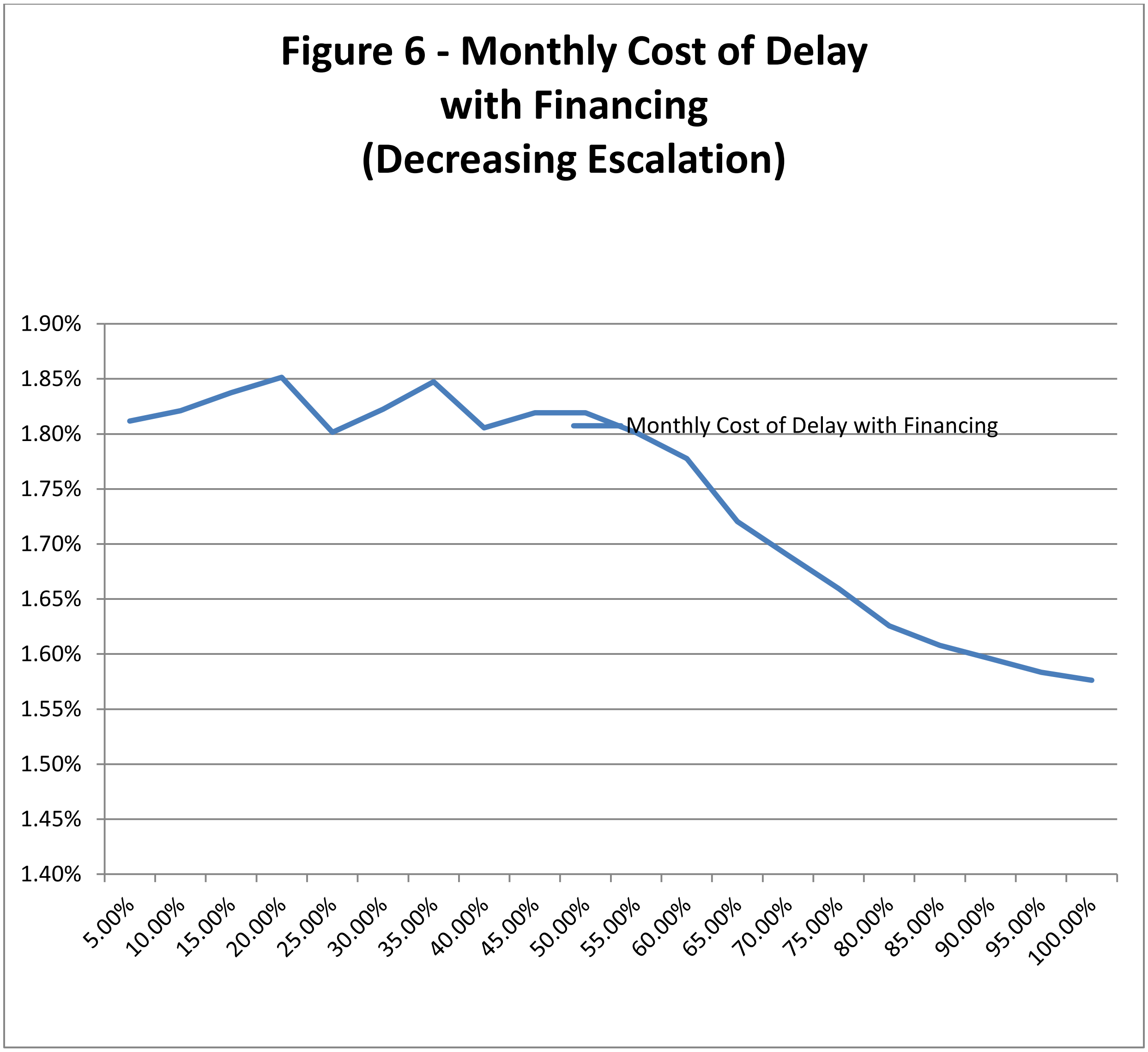
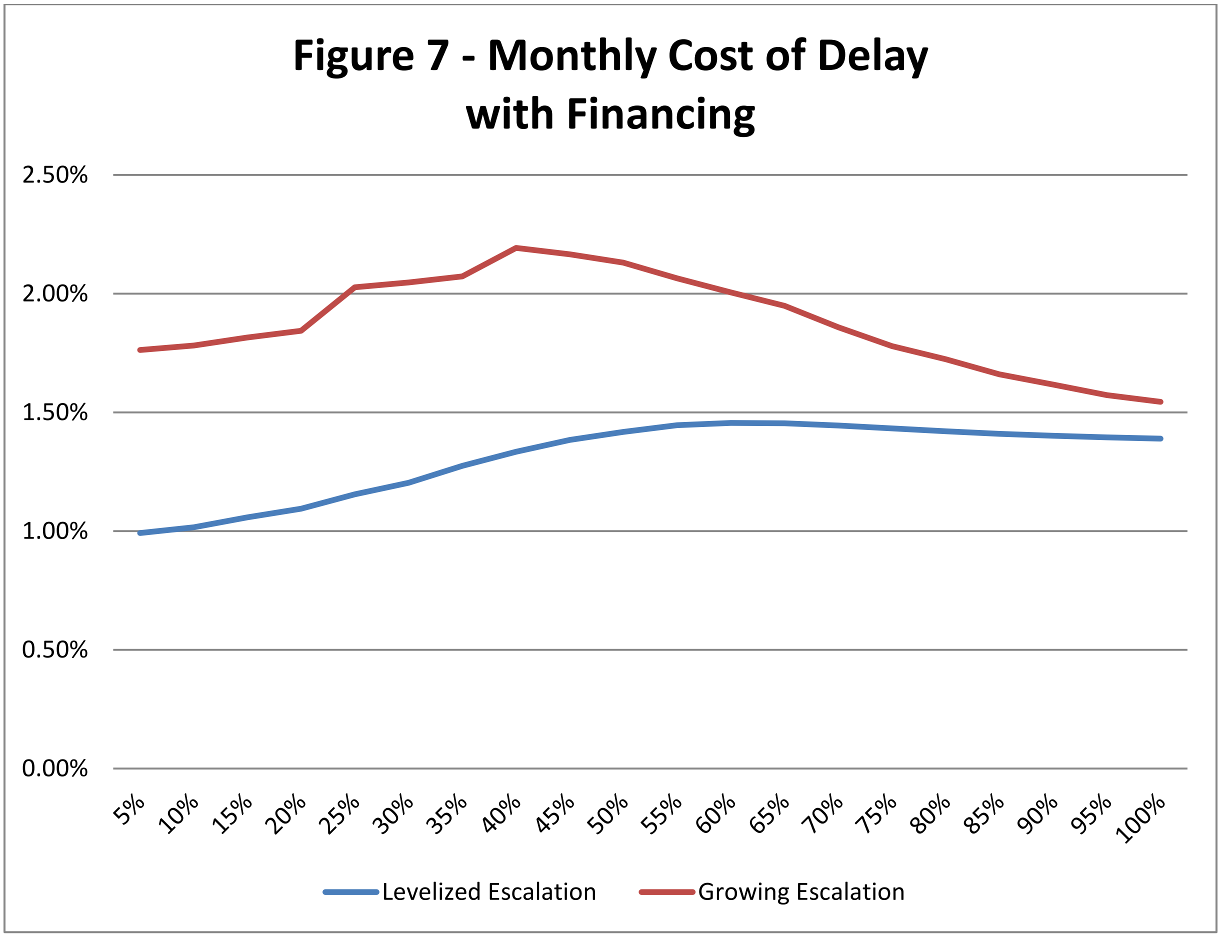


Figure 6 updates the case shown in Figure 3 to include the addition of the owner's cost of financing during a period of declining escalation. The sawtooth behavior is driven by step changes in escalation rates that become less significant in driving the overall shape of the curve as escalation builds. Overall delay costs measurably exceed those observed in Figure 3.

It is worth directly comparing the monthly cost of delay for levelized escalation and growing escalation (starting at the same level) with owner's financing costs included.

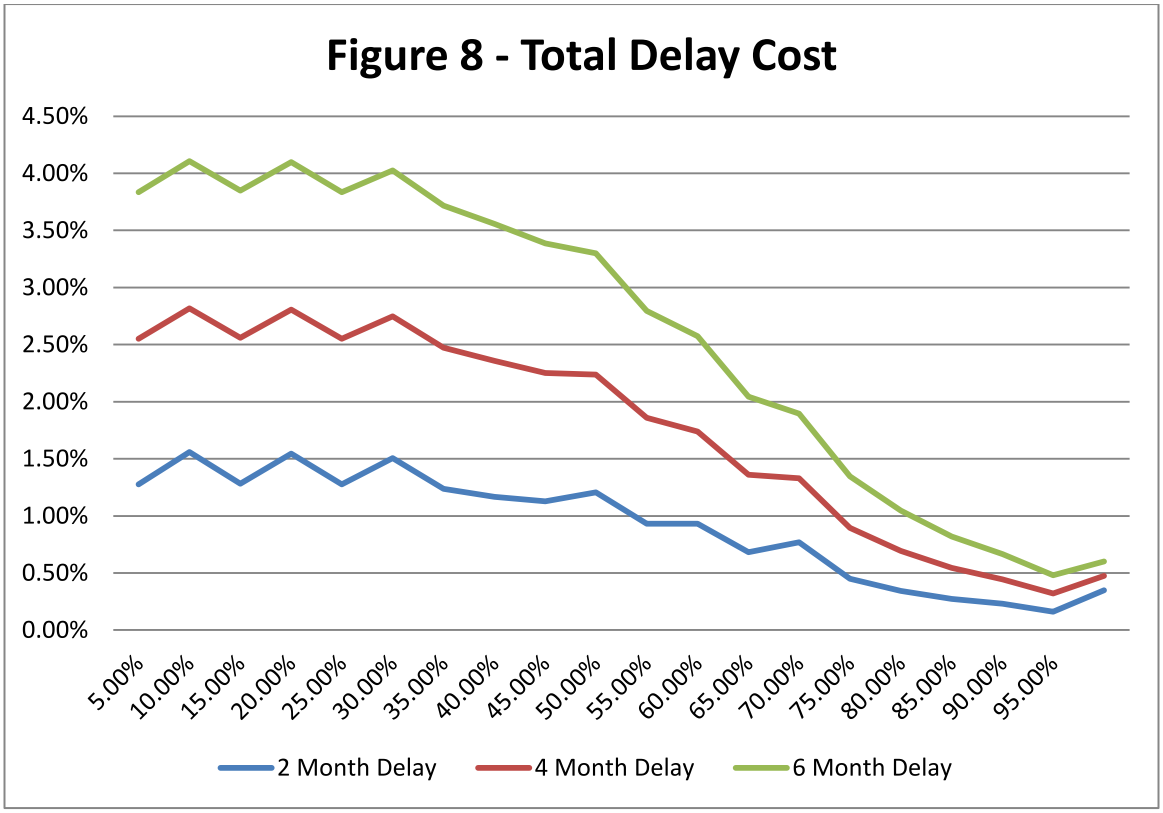
Figure 7 illustrates the importance of carefully modeling escalation for the entire project period in order to better appreciate the true cost of delay that may be experienced.



The importance of more accurate escalation modeling is particular acute in the first half of the project period but remains important in all cases considered.

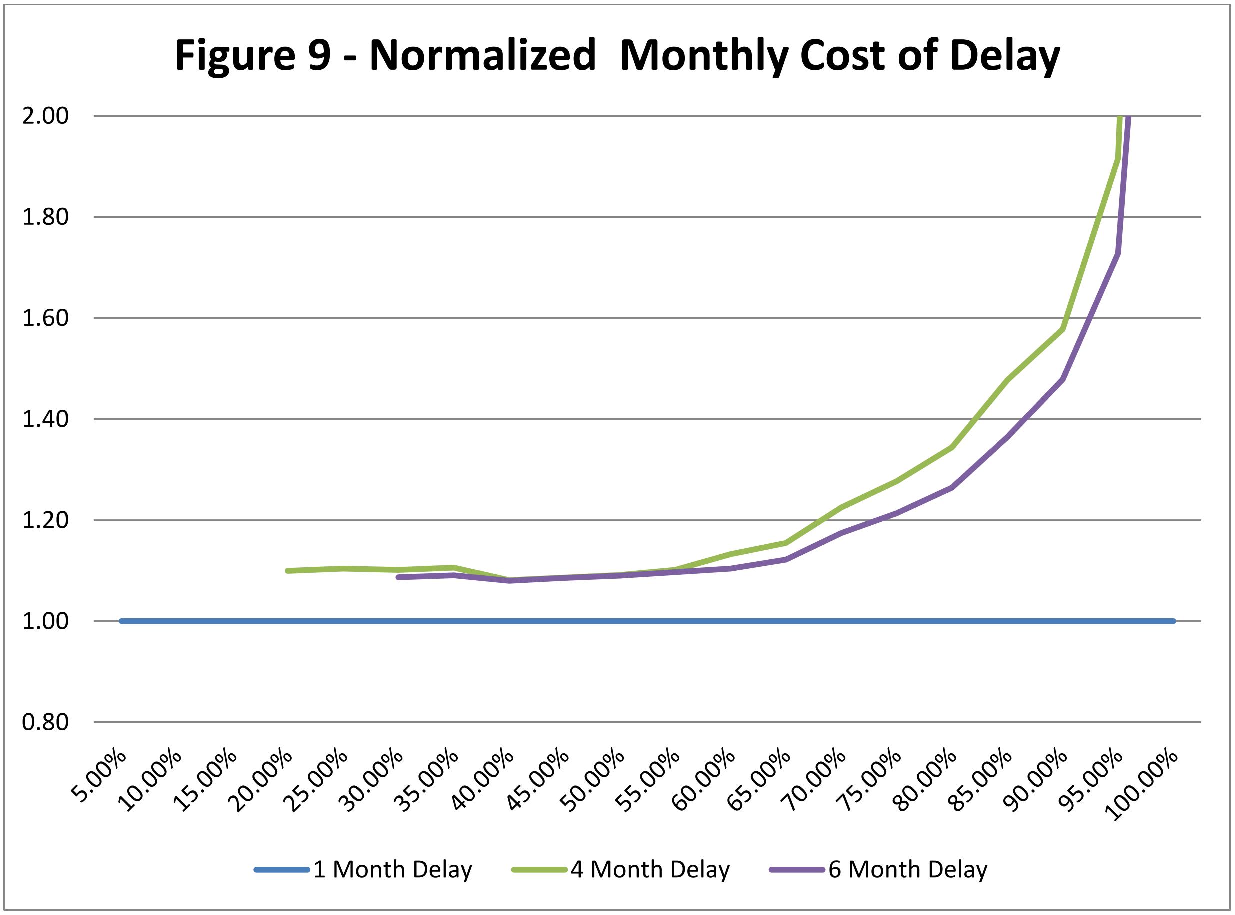
Sensitivity to Delay Duration

Let us return now to the contractor's perspective where escalation and general conditions costs are considered but the owner's cost of finance is not included. Looking at a project example where escalation is level throughout the project period we can now test the cost of delay for longer duration delays. In Figure 8, the cost of delay curves are plotted for two, four and six month delays.



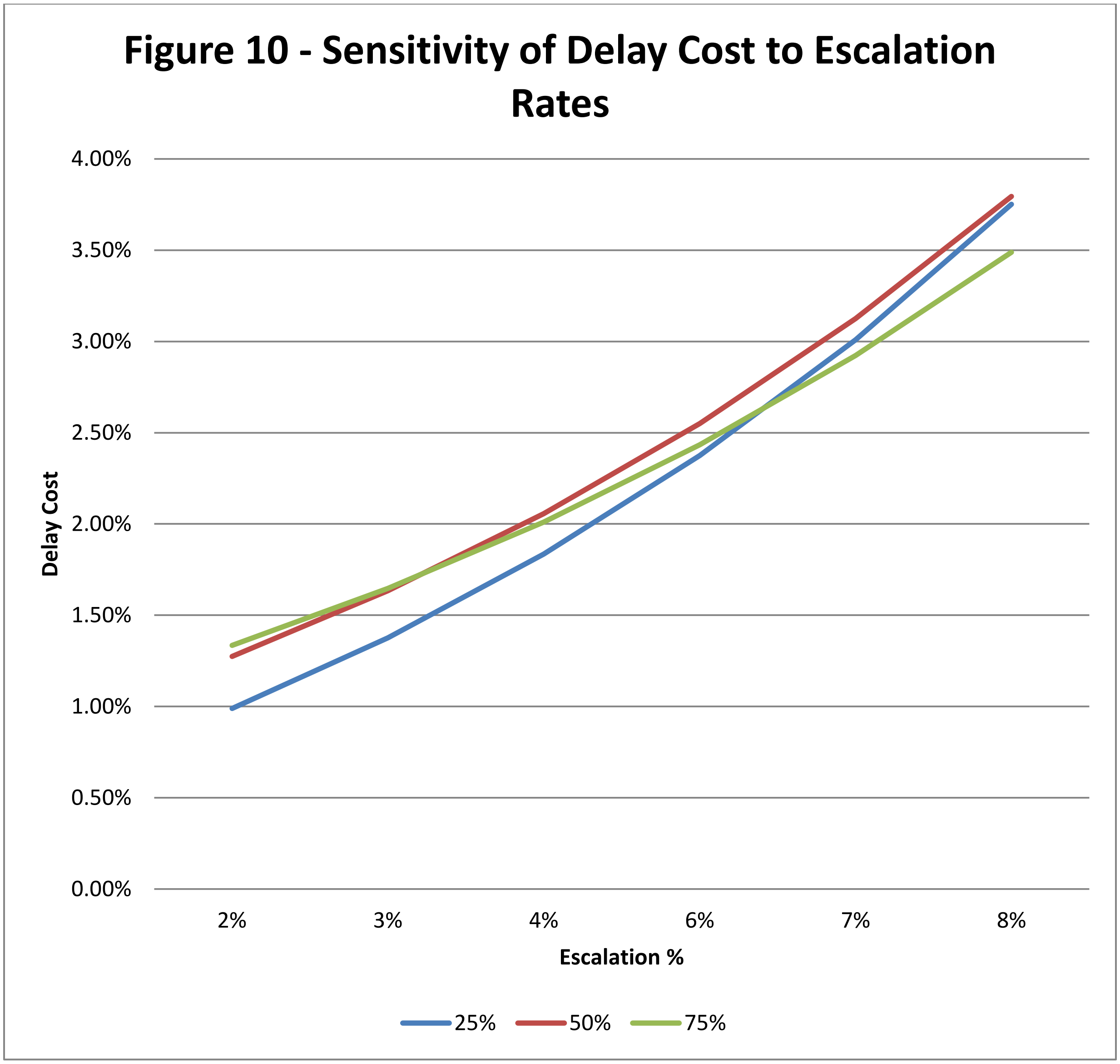
Delay costs associated with longer durations are higher, driven by continuing general conditions costs and an extended escalation period.

Figure 9 provides a different perspective on extended duration delays by looking at the average monthly cost of delay during the delay period in relation to the cost of a single month of delay. While these costs have been plotted against original schedule durations, these delay periods extend measurably beyond the original schedule and thus the results reflected in Figure 8 are more useful in my view. Importantly, **longer duration delays are more deleterious especially when they occur at later stages of project execution.**



Sensitivity to Escalation Rate

We have seen the interplay of extended general conditions costs, escalation on uninstalled balances and in the case of the owner's perspective on the cost of delay, the cost of extended financing period before revenue service. Figure 10 now looks at sensitivity of the cost of delay to escalation rate. The particular case analyzed assumed a constant delta between escalation rate and the weighted average cost of capital, in effect reflecting a "real cost" of money. Escalation was assumed to be level throughout the project period but a constant 3% escalation rate was used between the time of the project estimate and the start of the project one year later in all cases.



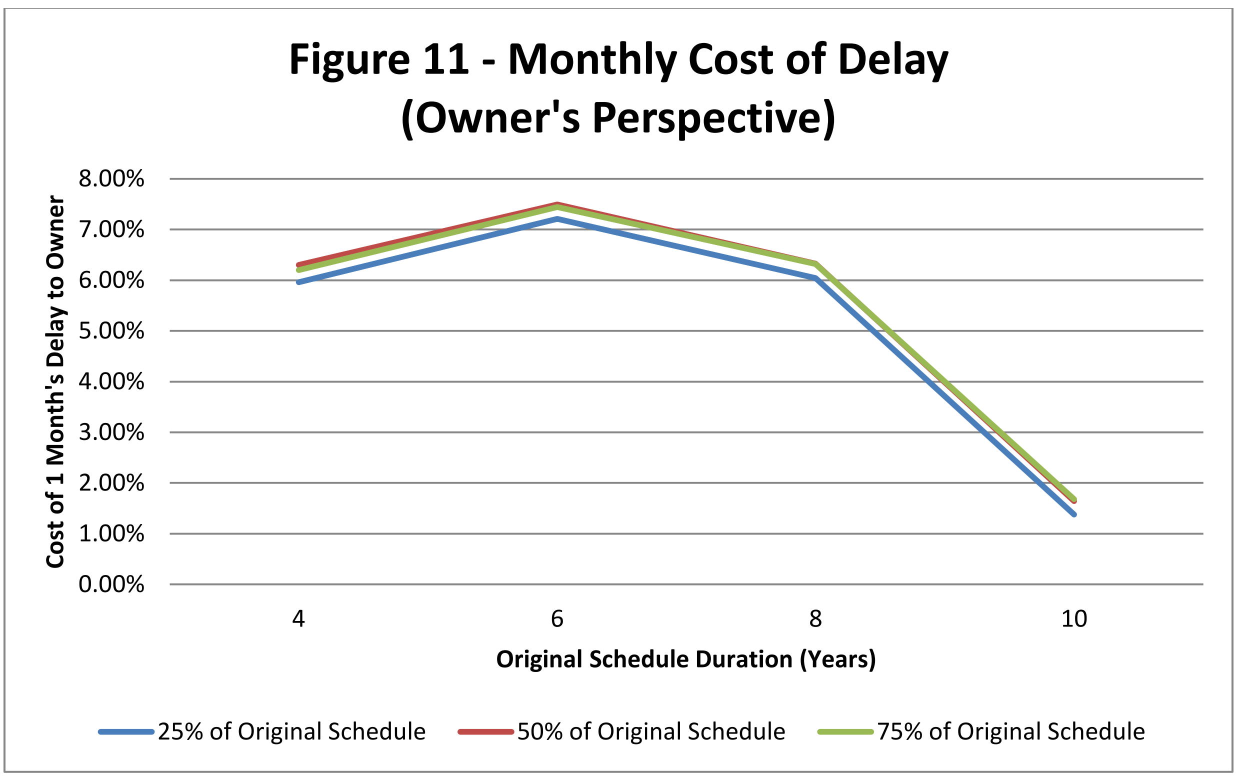
Three different points of delay have been considered, 25%, 50% and 75% of original project schedule. As expected, delay costs rise with increasing escalation rates (2% to 8%), **with earlier project phases (25%) more sensitive to escalation rate increase than later project phases (75%)**. The interplay of general conditions cost, escalation rate and WACC level influence the level and shape of the delay cost curves at each project time point.

Sensitivity to Schedule Duration

In each of the cases considered to this point an original project schedule of 10 years was assumed. Figure 11 now looks at the sensitivity of the monthly cost of delay to original project schedule adopting the owner's perspective with the cost of finance included. The difference is significant and acts to highlight the importance of timely decision making by the owner at all stages of the project. In that many project schedules are shorter than the 10 years assumed in the prior analyses, the impact of delay is even greater than that previously outlined.

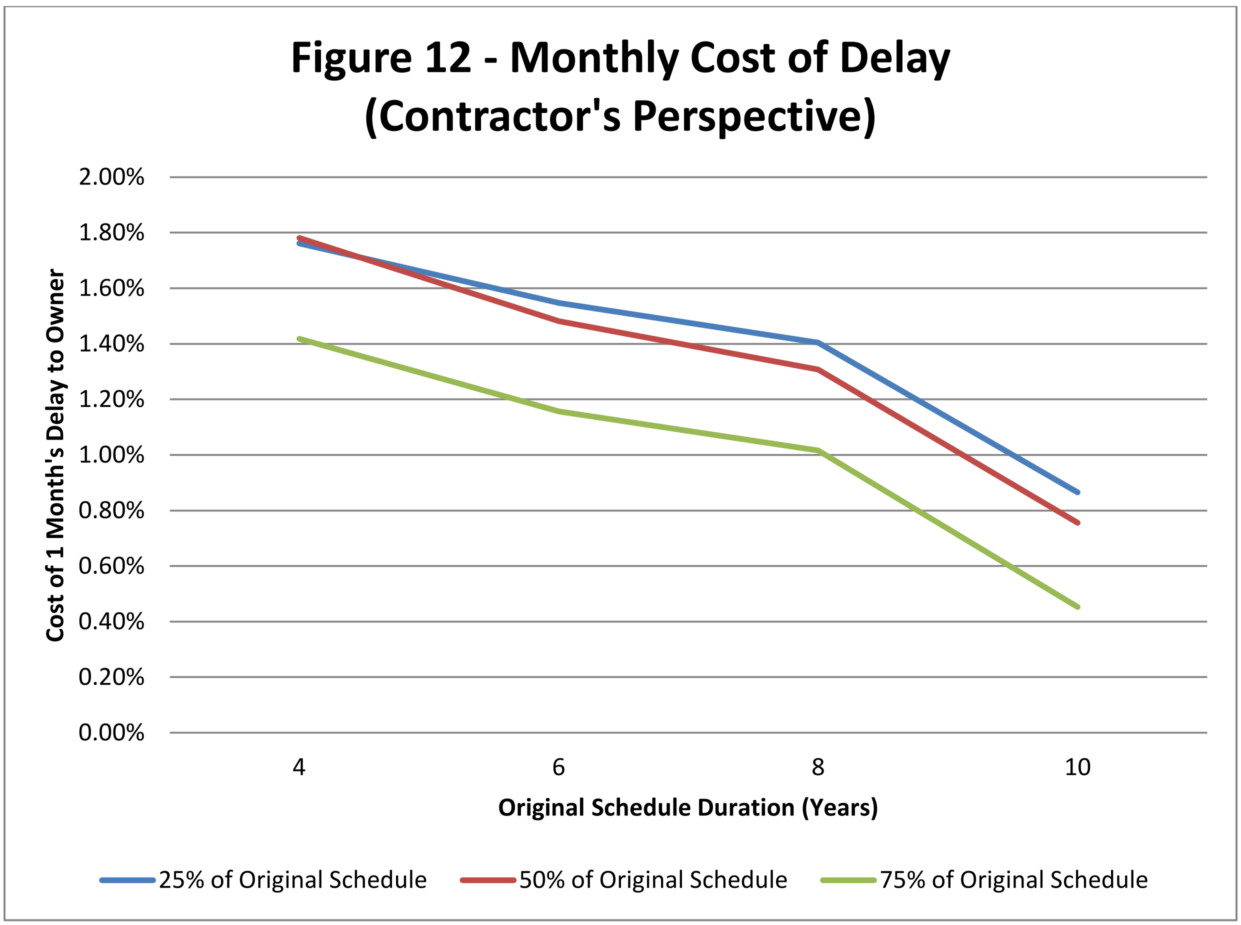
The relationship of escalation and financing rates creates a maximum impact for a 6 year schedule duration given all other assumptions with a cost of delay approximately 5X what is seen in the 10 year schedule which was used in all prior cases evaluated.

From the owner's perspective, the point in time at which the delay occurs is less significant than the original schedule duration of the project.



The General Contractor's view of delay cost as a function of original schedule duration differs from that of the owner since he does not experience the financing costs that the owner incurs. Figure 12 looks at the comparable delay cost versus schedule duration from the contractor's point of view. The absence of financing costs in delay cost considerations eliminates the duration related maxima observed by the owner. For the contractor, the cost of a month's delay decreases as a percentage of original project cost as project schedule grows in duration.

Unlike the owner, the contractor's view is more sensitive to when the delay occurs with early delays being more significant (ignoring impacts on productivity) because of the higher levels of escalation he experiences. These differing views are reflected in the contractor's desire to receive necessary approvals from the owner to proceed full speed ahead.



Estimating the Impact of Delay on Productivity from Retrograde Learning Curve

Estimating the impact of delay on productivity is the subject of extensive research in the engineering and construction industry. In such estimates principal factors to be considered include:

- The traditional learning curve or production function that best characterizes uninterrupted productivity improvement as the project progresses
- The maximum productivity rates realized as it relates to average productivity
- The amount of learning curve and therefore associated productivity rates during the delay period

For purposes of better dimensioning the cost of delay by including the increased cost associated with lost productivity from a retrograde learning curve we constructed a simple model of productivity over the project's duration. It is not intended to suggest that this is an accurate representation applicable to all major engineering and construction projects but rather a reasonable first approximation for purposes of this cost of delayed decision making analysis. The approach used differs from the so called "measured mile" approach by specifically including a loss of learning curve during the delay period. For purposes of this analysis we assumed:

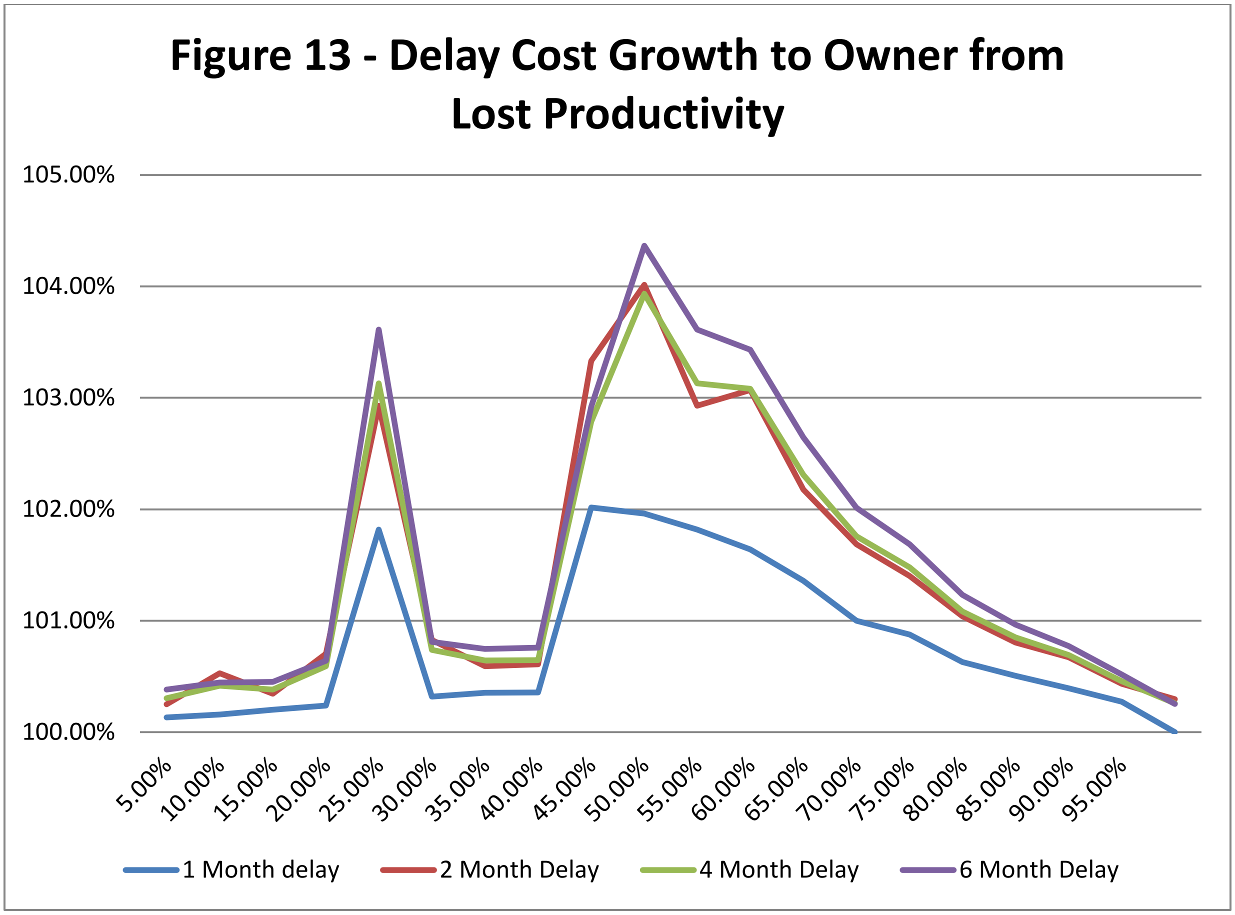
- Productivity during the first 5% of the project was at 50% of average productivity
- Maximum productivity is 150% of average and was reached at 50% of the project schedule

Average productivity was calculated as being achieved at 43% of the project's original schedule based on the above assumptions

The impact of delay on productivity was calculated as the loss of productivity based on 50% of the difference between the productivity rate at the time the project delay began and the productivity rate at an earlier period of time determined by subtracting the delay duration to model a loss of learning curve. This lost productivity factor was then modeled as increased labor costs over a period of time equal to the delay duration. Labor costs were assumed to represent 40% of period expenditures based on experience in the heavy civil industry.

Project delays within the first 5% of project duration were assumed to have no impact while those after peak production had been reached assumed to decline to values associated with the period prior to peak production being reached.

Figure 13 illustrates the percentage growth in delay cost as viewed by the owner (cost of financing included) as a function of delay duration and timing. The modest values reflect the conservative modeling of disruption and an absence of rework or constraints.



The cost of delay growth experienced by the contractor will be a higher percentage since it will be added to a smaller cost of delay that ignores growth in financing cost. By comparison, the contractor will experience a 6.45% growth in the cost of delay at the midpoint of the original schedule in the case of a 6 month delay. This compares with the 4.37% growth as seen from the owner's perspective.

"...loose not an hour"

- Nelson

Summary

Timely decision making is essential to effective project execution and lack of strong risk and cost based governance processes can have significant impacts in overall costs experienced by both the general contractor and owner. These impacts are a function of many factors including:

- Baseline project cost
- General escalation level
- Change in escalation rate over the project performance period
- Level of general condition costs
- Proportion of project costs subject to learning curve effects
- Weighted average cost of capital
- Delay duration
- Point in time when delay occurs

The perspectives of the contractor and owner differ significantly on the total cost of delay but governance processes intended to promote the owner's interests would be well served by adopting the more comprehensive cost view of the owner as described in this paper.

A $ 4 billion project (not uncommon in the world of large infrastructure and industrial projects) subject to a delay of one day in decision making would increase an owner's cost by $10 million. ***Was the day lost in decision making worth it?***

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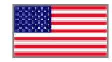
About the Author



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Bob is a member of the ASCE Industry Leaders Council, National Academy of Construction and a Fellow of the Construction Management Association of America. Bob served until 2006 as one of three U.S. presidential appointees to the Asia Pacific Economic Cooperation (APEC) Business Advisory Council (ABAC), working with U.S. and Asia-Pacific business leaders to shape the framework for trade and economic growth and had previously served as both as Chairman of the Engineering and Construction Governors of the World Economic Forum and co-chair of the infrastructure task force formed after September 11th by the New York City Chamber of Commerce. Previously, he served as Chairman at Parsons Brinckerhoff (PB), one of the world's leading engineering companies. Bob Prieto can be contacted at Bob.Prieto@fluor.com.