**P3 Delivery Benefit-Cost Analysis Exercise Answers**

**ANSWERS ARE SHOWN IN BOLD RED FONT**

**Objectives of this exercise**

* Learn how to enhance P3 Value-for-Money (VfM) analysis using benefit-cost analysis methods to include the societal perspective.
* Learn how test the impacts of alternative travel growth projections.
* Learn how to test the impacts of P3 quality of service assumptions.

**Project Background**

A study was done previously by a state DOT to estimate Value for Money of P3 delivery for a highway project. The various inputs required for the analysis are included in the P3-VALUE 2.0 spreadsheet model. The project information is as follows:

* 20 miles highway expansion
* Expansion from 3 lanes to 5 lanes in each direction:
  + 3 General Purpose Lanes (GPL)
  + 2 Managed Lanes (ML)
* Costs under PSC (excluding risks and financing):
  + Pre-construction & construction: $25M and $400M respectively
  + Routine O&M: $4M per year
  + Major maintenance: $10M (every 8 years)
* Preconstruction under PSC starts in 2015; 2 years duration
* Construction duration under PSC: 4 years
* Operations period under PSC: 40 years

**Analysis Steps**

**Part A:** Use the P3-VALUE Benefit-Cost Analysis training module to review:

1. How to develop the *Delayed* Public Sector Comparator
2. How to develop the Public Sector Comparator
3. How to develop the P3 Option
4. How to compare the alternatives from the perspective of society as a whole and identify:
   * Project benefits under delayed conventional delivery
   * Any incremental project benefits from an accelerated conventional project delivery
   * Any further benefits from P3 delivery

**Part B:** Test the impacts of uncertain travel growth assumptions on the analysis results.

**Part C:** Test the impact of P3 quality of service assumptions on the analysis results.

**Part A: P3 Delivery Benefit-Cost Analysis**

1. Open P3-VALUE 2.0 Excel file.
2. When opening the file, Excel may prompt you to approve the use of macros. To do so, click “Enable editing” and/or “Enable content” on the yellow bar across the top of the screen.
3. After the model opens, the following user form will appear.



1. Select the “Training Navigator” to access the training modules. The “Training Navigator” contains four training modules that provide limited access to only the most relevant inputs and outputs for a particular training session.
2. Select “Module 2: Project Delivery Benefit-Cost Analysis” and proceed with the steps below (Note that the Training Navigator window may be closed and reopened at any point. Also, the tool has already been optimized and therefore is not required for the remainder of the task).

***Step 1: Review the Delayed Conventional Delivery (PSC) Option***:

The Delayed PSC is comprised of: (1) Costs; (2) Risks (to be covered in topical webinar 4 on Risk Assessment); and (3) Benefits.

Review the timing, costs, and benefits inputs for the Delayed PSC as outlined below. Note that the only difference between Delayed PSC and PSC is the pre-construction start year and construction start year, with duration being the same.

* Timing (***InpTiming&Cost***)
  + Pre-construction start year
  + Pre-construction & construction duration
* Costs (***InpTiming&Cost***)
  + Costs for pre-construction & construction
  + Costs for operations
* Timing of expenses & traffic ramp-up (***InpSeries***)
* Benefit-cost analysis inputs (***InpBCA***)
  + Duration of construction and O&M activities that affect traffic flow, and speed adjustment factor to account for delays during those activities
  + Incident-related speed adjustment factor to account for incident-related travel delays averaged annually)
  + Pavement quality IRI to account for fuel and non-fuel travel cost changes relative to No Build.

Review and record below the delayed PSC net benefits (see ***PDBCA Output Summary*** sheet).

|  |  |
| --- | --- |
| **Item** | **Delayed PSC ($M)** |
| Social benefits (sum row 5-12) | **2,333** |
| No Build cost savings (row 13) | **160** |
| Construction costs (row 14) | **(333)** |
| Operations costs (row 15) | **(81)** |
| Risks (sum row 16-18) | **(262)** |
| **Total Net Benefits under Delayed PSC** | **1,817** |

Below, please respond to the following questions; we will also discuss them at the webinar:

1. Why are benefits due to construction-related travel delay differences (row 6) negative, while they are positive for O&M-related travel delays (row 7)?

**Unlike the No Build scenario, the Delayed PSC scenario will have construction, which initially results in the negative benefits due to construction activities in work zones. The O&M benefits, however, will be positive for the Delayed PSC because the construction will result in a road that is less expensive to maintain as well as requires maintenance activities that are shorter in duration as reflected in the “duration” inputs for O&M-related delays.**

1. Why are benefits due to fuel costs and emissions costs negative (rows 10 and 12 respectively), even though travel time benefits (row 5) are positive?

**The fuel and emissions costs are calculate based on pavement quality, fuel consumption rate, fuel price, segment length, and existing traffic. While the first four factors might reduce or maintain the same level of fuel and emissions costs, under Build scenarios there is a significant increase in traffic (“induced traffic”), which results in higher fuel and non-fuel vehicle operating costs, i.e., negative benefits. Furthermore, due to the expansion of the facility, speeds may be higher, leading to a further increase in fuel consumption and emissions. The travel time benefits are calculated based on congested speeds for each model, which is higher under the Delayed PSC and therefore positive. The savings are experienced by all traffic; however, due to the “rule of half” approach in calculating consumer surplus benefits for “new” traffic, each new traveler is estimated to receive only half of the savings received by existing travelers.**

1. Is the discount rate of 3% selected to calculate present values reasonable? Why?

**Yes, because it is in the range of the government accepted rate. In the PDBCA, the model uses the social real discount rate, which is theoretically the social discount rate that represents the opportunity cost of what else the Agency or government could accomplish with those same funds.**

1. Why are revenue benefits to the Public Agency not accounted for?

**Revenue benefits would be considered under the Value for Money analysis and not the BCA. Tolls are a transfer from users to the concessionaire/government and therefore do not change the overall societal welfare. Please note that tolls do play a role in calculating the benefits for induced traffic. For a detailed discussion on this, please refer to the Guide to P3-VALUE 2.0.**

1. Based on the analysis results, is implementing the project under delayed conventional delivery worthwhile? Why?

**Yes. Under the Delayed PSC the Total NPV of the costs and benefits as compared to the No Build scenario are a positive $1,817 M.**

***Step 2: Review the PSC assumed to be implemented in the same time frame as P3***:

The PSC is comprised of: (1) Costs; (2) Risks (to be covered in topical webinar 4 on Risk Assessment); and (3) Benefits.

As you did for the Delayed PSC, review the key project information in the input sheets of the model provided. Note that the only difference between Delayed PSC and PSC is the pre-construction start year and construction start year, with duration of each being the same.

* Timing (***InpTiming&Cost***)
  + Pre-construction start year
  + Pre-construction & construction duration
* Costs (***InpTiming&Cost***)
  + Costs for pre-construction & construction
  + Costs for operations
* Timing of expenses & traffic ramp-up (***InpSeries***)
* Benefit-cost analysis inputs (***InpBCA***)
  + Duration of construction and O&M activities that affect traffic flow, and speed adjustment factor to account for delays during those activities
  + Incident-related speed adjustment factor to account for incident-related travel delays averaged annually)
  + Pavement quality IRI to account for fuel and non-fuel travel cost changes relative to No Build.

Record below the PSC benefits and costs (see **PDBCA Output Summary** sheet) and compare them to Delayed PSC benefits and costs from Step 1:

|  |  |  |  |
| --- | --- | --- | --- |
| **Item** | **A. PSC benefits and costs ($M)** | **B. Delayed PSC benefits and costs ($M)** | **PSC difference ($M) (Col A – Col B)** |
| Social benefits (sum row 24-31) | **2,720** | **2,333** | **387** |
| No Build cost savings (row 32) | **199** | **160** | **39** |
| Construction costs (row 33) | **(386)** | **(333)** | **(53)** |
| Operations costs (row 34) | **(102)** | **(81)** | **(21)** |
| Risks (sum row 35-37) | **(321)** | **(262)** | **(59)** |
| **Total Net Benefits** | **2,111** | **1,817** | **294** |

Below, please respond to the following questions; we will also discuss them at the webinar:

1. Based on the analysis results, is advancing the project worthwhile? Why?

**Yes. By advancing the project, the total NPV of the benefits goes up by $294 M.**

1. Why are costs for Operations higher under PSC than under Delayed Conventional Delivery (i.e., Delayed PSC), even though the same delivery method is employed?

**Costs are higher because starting a project today is more expensive than starting a project in the future. There are more years of operations, which results in higher costs.**

1. Why are construction costs higher under PSC than under the Delayed PSC, even though the same delivery method is employed?

**Similar to the Operations costs, the Construction costs are encountered earlier and are therefore higher in NPV terms due to the time value of money.**

1. Why are social benefits higher under PSC than under the Delayed PSC, even though the same delivery method is employed?

**Under PSC the social benefits are $2,720 M while under the Delayed PSC they are $2,333 M. The difference is due to the earlier completion of the project (which will increase costs in NPV terms) and being able to generate Travel Time, Incident Delay, O&M Delay, Non-Fuel, and Accident benefits sooner and therefore for a longer period of time.**

***Step 3: P3 Option***:

P3 Option inputs comprise the following:

* **Costs:** PSC costs and timeline, but adjusted to take into consideration assumed P3 differences
* **Risks:** PSC risks, but adjusted to take into consideration assumed P3 differences
* **Benefits:** PSC benefits, but adjusted to take into consideration assumed P3 differences

Potential P3 differences relative to the PSC that affect societal costs and benefits can include:

* Longer project preparation and shorter construction duration
* Cost and risk differences (e.g., higher public procurements costs or lower lifecycle cost)
* Service quality changes resulting in differences in user benefits and externalities

Review differences assumed in***InpTiming&Cost****,* ***InpSeries, & InpBCA****.*

* Timing (***InpTiming&Cost***)
  + Pre-construction start year
  + Pre-construction & construction duration
* Costs (***InpTiming&Cost***)
  + Costs for pre-construction & construction
  + Costs for operations
* Timing of expenses & traffic ramp-up (***InpSeries***)
* Benefit-cost analysis inputs (***InpBCA***)
  + Duration of construction and O&M activities that affect traffic flow, and speed adjustment factor to account for delays during those activities
  + Incident-related speed adjustment factor to account for incident-related travel delays averaged annually)
  + Pavement quality IRI to account for fuel and non-fuel travel cost changes relative to No Build.

Record below the P3 delivery benefits and costs (see***PDBCA Output Summary*** sheet) and compare them to PSC benefits and costs from Step 2:

|  |  |  |  |
| --- | --- | --- | --- |
| **Item** | **A. P3 benefits and costs ($M)** | **B. PSC benefits and costs ($M) from Step 1** | **P3 difference ($M) (Col A – Col B)** |
| Social benefits (sum row 43-50) | **2,860** | **2,720** | **140** |
| No Build cost savings (row 51) | **208** | **199** | **9** |
| Construction costs (row 52) | **(378)** | **(386)** | **8** |
| Operations costs (row 53) | **(96)** | **(102)** | **6** |
| Risks (sum row 54-56) | **(299)** | **(321)** | **22** |
| **Total Net Benefits** | **2,295** | **2,111** | **184** |

Below, please respond to the following questions; we will also discuss them at the webinar:

1. Compare the P3 outputs with those for the PSC. Is P3 delivery worthwhile from a societal perspective? Why?

**Yes. Under the P3 scenario there is an extra NPV of $184 M in benefits to society.**

1. Why are No Build O&M cost savings higher for the P3 than that for the PSC?

**No build O&M cost savings are higher under the P3 option because P3 construction is completed a year earlier than it would be under the PSC. As a result, O&M cost savings begin earlier and accrue for an extra year.**

1. Compare the social benefits for P3 with the social benefits for conventional delivery (PSC). Why are the benefit estimates different?

**Compared to PSC delivery, the P3 delivery benefits are higher because under this scenario the construction is completed a year earlier, allowing for net savings to begin earlier. Also, P3 differences related to pavement ride quality, work zone practices, and incident response result in lower travel delays, reduced vehicle fuel and non-fuel operating costs and higher usage during traffic ramp up in the early rears. On the costs side, there is a 10% cost efficiency that the private delivery is assumed to have throughout the construction and maintenance periods. Risks are also assumed to be 10% lower (to be discussed in the webinar on risk assessment).**

**Part B: Test Impacts of Uncertain Traffic Growth Projections**

Analyze the effect of traffic assumptions on the previously estimated net benefits by changing the PDBCA traffic sensitivity factor (F33 in ***InpTraffic&Toll***) from 100% first to 80%, then to 120%, and finally to 0%. Please note that the sensitivity factor is only applied to traffic above the No Build base year traffic (i.e., traffic growth).

After each input change, recalculate the spreadsheet (go to “Formulas” on the menu bar and click on “Calculate now” if “Automatic” is not checked under “Calculation options” or click calculate in the bottom left corner of the sheet) and record the revised NPV estimates *(****PDBCA Output Summary****) (Note you do not have to optimize the model):*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Net benefits @ 100% of traffic growth ($M)** | **Net benefits @ 80% traffic ($M)** | **Net benefits @ 120% traffic ($M)** | **Net benefits @ 0% traffic growth ($M)** |
| A. NPV of net benefits under Delayed PSC | **1,817** | **1,524** | **2,194** | **785** |
| B. NPV of net benefits under PSC | **2,111** | **1,804** | **2,506** | **1,015** |
| **C. Difference between A and B, i.e., NPV of project acceleration** | **294** | **280** | **312** | **230** |
| D. NPV of net benefits under P3 Option | **2,295** | **1,984** | **2,694** | **1,177** |
| **E. Difference between B and D, i.e., NPV of P3 delivery** | **184** | **180** | **188** | **162** |

Below, please respond to the following questions; we will also discuss them at the webinar:

1. Would accelerated project delivery be worthwhile under alternative travel assumptions that are 20% lower? Would it be worthwhile if they were 20% higher? Why do you think so?

**Accelerated project delivery would be worthwhile with travel assumptions that are 20% higher. Compared to the 100% level, the higher percentage yields an $18 M of NPV of additional benefits. A higher traffic projection will result in larger benefits gained from factors such Travel Time and Incident Delays. While a 20% lower growth projection results in lower net benefits, the NPV of net benefits of acceleration is still positive, indicating that project acceleration would still be worthwhile under the lower growth scenario.**

1. Would P3 delivery be worthwhile under alternative travel assumptions that are 20% lower? Would it be worthwhile if they were 20% higher? Why do you think so?

**P3 delivery would be worthwhile with travel assumptions that are 20% higher. Compared to the 100% level, the higher percentage yields an $4 M of NPV of benefits. Again, a higher traffic projection will result in larger benefits gained from factors such Travel Time and Incident Delays. While a 20% lower growth projection results in lower net benefits, the NPV of net benefits with P3 delivery is still positive, indicating that P3 delivery would still be worthwhile under the lower growth scenario.**

1. Would accelerated project delivery and P3 delivery be worthwhile under alternative travel assumptions that assume no traffic growth at all?

**Yes. When assuming no traffic growth at all and compared to the No Build scenario, the accelerated project delivery still results in a higher NPV of $230 M in total benefits. When the P3 scenario is compared to the No Build case there is a higher NPV of $393 in total benefits.**

**Part C: Test Impacts of P3 Quality of Service Assumptions**

For the 0% traffic growth scenario, check one by one the effect of key P3 quality of service assumptions on NPV. After each input change, recalculate the spreadsheet and record the revised NPV estimates. Each model run should be additive, i.e., do not reverse any changes you made in the prior run.

Step 1: Early Construction completion – Increase P3 construction duration to 4 years to match PSC schedule (L14 in ***InpTiming&Cost***), hit “Calculate”, and adjust ***InpSeries*** accordingly so that 25% of construction cost is expended in each of the 4 years (row 66-73). *Optimize the model* and record the results below.

Step 2: Pavement Ride Quality – Eliminate the improvement in P3 ride quality by increasing the International Roughness Index (IRI) so that it is the same as that for the PSC (140) (F70 in ***InpBCA***). Hit “Calculate” and record your results below. *(Note you do not have to optimize the model. Also, since the P3 assumed difference was small, you will not see any impact due to its insignificance ).*

Step 3: Travel delays related to construction and O&M – Eliminate the reduction in duration of construction and O&M activities for P3 by increasing the hours per day for each input so that they are the same as the PSC inputs (F27 and G27 in ***InpBCA***). Hit “Calculate” and record your results below. *(Note you do not have to optimize the model).*

Step $: Travel delays related to incidents – Eliminate the reduction in speed adjustment for incident delays for P3 by increasing the % speed reduction for P3 so that it is the same as the one for PSC (F39 in ***InpBCA***). Hit “Calculate” and record your results below. *(Note you do not have to optimize the model).*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test Scenario** | **A. NPV of PSC ($M)** | **B. NPV of P3 Option ($M)** | **C. Difference between P3 and PSC ($M) = Col B – Col A** | **Incremental difference ($M) compared to prior model run** |
| Base Case assumptions with 0% traffic growth scenario (from Part B) | **1,015** | **1,177** | **162** | **N.A.** |
| 1. No early completion | **1,007** | **1,088** | **81** | **(81)** |
| 2. No ride quality improvement | **1,007** | **1,088** | **81** | **0** |
| 3. No reduction in const. and O&M duration | **1,007** | **1,084** | **77** | **(4)** |
| 4. No reduction in incident response time | **1,007** | **1,053** | **46** | **(31)** |

Below, please respond to the following questions; we will discuss at the webinar:

1. Which P3 service quality improvement assumption appears to have the biggest impact on NPV?

**Early completion appears to have the biggest impact on NPV. When there is no early completion, the NPV of the P3 total benefits drops by $81 M.**

1. If there were no service quality improvements under P3, would P3 delivery still be worthwhile from a societal perspective?

**Yes. While the net benefits would not be as large, the NPV of total P3 net benefits would still be greater than the NPV of total PSC net benefits. These remaining positive net benefits are due to assumed cost and risk reductions under P3 delivery, as discussed in the previous exercise on VfM analysis.**