The Economics of Innovation Procurement

2nd SEREN3 Training for stakeholders on PCP/PPI in Secure Societies
30th of May 2017, Warsaw, Poland
Outline

- Introduction to procurement economics
- Innovation procurement
  - Pre-commercial Procurement (PCP)
  - Public Procurement of Innovative Solutions (PPI)
- Introduction to the Business Case Methodology
- Economic evaluation – theory and practice
  - Uncertainty - Justifying PCP
  - Time - Discounting, Net Present Value, Returns
  - The stand-alone PPI
  - Reaping rewards – Royalty Schemes
- Discussion
What is Procurement Economics

- Public Procurement is ~18% of European GDP
- To support demand-side innovation
  - Demand-pull vs supply-push
- To help procurers achieve:
  - Primary goals – service improvement, cost reduction
  - Secondary goals – innovation, sustainability
- To support rational and transparent decision-making
  - Building a business case
  - Gaining internal project support
Pre-Commercial Procurement (PCP)

- Develop and test new solutions through R&D to meet the challenge identified
- Purchase R&D to
  - Steer the development of solutions to procurers’ needs
  - Gather knowledge on pros/cons of alternative solutions
  - Support a competitive supply base (avoid later lock-in)
- Purchase R&D from several suppliers in parallel (comparing alternative solution approaches)
- Closed competition and evaluating progress after critical milestones (design, prototyping, testing)
- (IPR-related) Risks and benefits of R&D are shared between procurer and suppliers - Maximizes incentives for wide commercialization
Phases of PCP

R&D / Pre-commercial Procurement (PCP)

Phase 0
Curiosity Driven Research

Phase 1
Solution design
Supplier A
Supplier B
Supplier C
Supplier D

Phase 2
Prototype development
Supplier B
Supplier C
Supplier D

Phase 3
Original development and testing of limited volume of 1st test products/services
Supplier B
Supplier D
Public Procurement of Innovative Solutions (PPI)

- Incremental innovation or scaling up to meet the identified challenge
  - No R&D takes place – is already completed, or not required to solve the challenge
- When a solution is
  - Near to the market
  - Already on the market, but in small quantities
- Procurer acts as launching customer / early adopter / first buyer
Innovation procurement
Phases of a PPI

1. Announce intention to buy a critical mass of innovative solutions triggers industry to bring products to the market
   - With a desired price : quality ratio
   - Within a specific time
2. Verify whether what market delivers the desired quality/price – e.g. via a test and/or certification
3. Purchase a significant volume of innovative solutions.
Business Case Methodology

- To help public procurers engage in innovation procurement by reducing risks and identifying incentives
- ... By identifying the procurer’s need for innovation and private actors’ abilities to meet this need
- Six steps:
  1. Needs identification and assessment;
  2. Prior art analysis and intellectual property rights (IPR) search;
  3. Analysis of the standards’ landscape;
  4. Economic calculations; and
  5. Open market consultation
- Procurers can directly apply the methodology during the preparatory phase
An ICT hardware solution? - The Case Study

- There are currently 100 units of an ICT technology
- The technology is non-functioning 5% of the time
- Repair costs are €27,50/hour, and repair takes 9 hours
  - Total monthly cost: €27,50/hour x 9 hours x 100 units = €99,000/month
- A procurer wants to reduce the down-time by half
  - Potential monthly savings: €99,000/month ÷ 2 = €49,500/month
- The procurer estimates the price of the solution (all units) at €100,000
What the procurer needs to decide

- Whether to purchase **R&D services**, or conduct a **PCP**?
- Would a PCP+PPI be **profitable**?
- How long do we have to implement the new technology before we **break even**?
- What royalty rate should we offer as a **profit-sharing agreement**?
Uncertainty and the PCP
Uncertainty – Probabilities

- No future is certain
- Uncertainty can come from
  - Technology unknowns – costs, performance, reliability
  - Market unknowns – prices, economies of scale, openness
- We introduce probability to account for uncertainty
  - Is always a factor between 0 (will never happen) and 1 (will always happen)
  \[ 0 < q < 1 \]
- Values with uncertainty are expected, not real

Every day I walk my dog in the morning. Twice a week, we see joggers.
- Throughout the entire week, you have a 29% (2 days / 7 days) chance of seeing joggers.
  \[ q = .29 \]
Justifying a 3-phase PCP - Overview

- The probability that the full R&D budget has to be paid even if the benefits don't occur is always lower in a PCP (3-phase vs 1-phase)
- Based on a market consultation, the procurer estimates the following probabilities of success at each phase:
  - S1 $q_1 = 0.70$
  - S2 $q_2 = 0.75$
  - S3 $q_3 = 0.80$

<table>
<thead>
<tr>
<th>Project Phase</th>
<th>Expense</th>
<th>Probability</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCP phase 1</td>
<td>200,000</td>
<td>0.70</td>
<td>$q_1$</td>
</tr>
<tr>
<td>PCP phase 2</td>
<td>300,000</td>
<td>0.75</td>
<td>$q_2$</td>
</tr>
<tr>
<td>PCP phase 3</td>
<td>500,000</td>
<td>0.80</td>
<td>$q_3$</td>
</tr>
<tr>
<td>Purchase</td>
<td>100,000</td>
<td>0.42</td>
<td>$q = q_1 \cdot q_2 \cdot q_3$</td>
</tr>
</tbody>
</table>

- Then the R&D success rate is $q_1 \cdot q_2 \cdot q_3 = 0.7 \cdot 0.75 \cdot 0.8 = 0.42$. Therefore $q = 0.42$
Justifying a 3-phase PCP - Costs

Costs for the public procurer in an all-in-one R&D services contract

\[ C_1 = \begin{cases} (1.000.000 \, + \, P) & \text{with probability } q \\ 1.000.000 & \text{with probability } 1 - q \end{cases} \]

\[ EC_1 = (1.000.000 \, + \, P)q + 1.000.000(1 - q) \]

\[ EC_1 = €1.042.000 \]

The probability of complete loss is \( 1 - q = 1 - 0.42 = 58\% \)

Costs for the public procurer in a PCP contract with 3 phases

\[ C_3 = \begin{cases} (1.000.000 \, + \, P) \, + \, 200.000 & \text{with probability } q \\ 200.000 + 300.000 & \text{with probability } 1 - q_1 \\ 200.000 + 300.000 + 500.000 & \text{with probability } q_1 \times (1 - q_2) \end{cases} \]

\[ EC_3 = (1.000.000 \, + \, P \, + \, 200.000)(1 - q_1) + 500.000(q_1(1 - q_2)) + 1.000.000(q_1q_2 - q_1q_2q_3) \]

\[ EC_3 = €714.500 \]

The probability of complete loss is \( q_1 \times q_2 - q_1 \times q_2 \times q_3 = 10.5\% \)
Justifying a 3-phase PCP - Benefits

- Benefits for each are the same, where \( t \) is the number of months the solution is implemented

\[
B = \begin{cases} 
49.500 \times t & \text{with probability } q \\
0 & \text{with probability } 1 - q
\end{cases}
\]

\[
EB = 49.500tq + 0(1 - q)
\]

- If the procurer estimates implementation of the resulting PPI over 48 months, then

\[
EB = 49.500 \times 48,42 = €997.290
\]

- We can now calculate the Return on Investment (ROI)

\[
ROI = \frac{EB - EC}{EC}
\]

- For the 3-phase PCP, the ROI is 37.4%, compared with the single stage of -4.2%
Time & Value
Time – discounting

- For a more accurate estimates, we need to introduce time
- To do this, we use a discount factor \( \delta \), based on a discount rate \( i \)
  \[
  \delta = \frac{1}{(1+i)^t}
  \]
  - Every month \( t \), the discount factor decreases
  - The further in the future a cost or benefit is incurred, the less it affects our present value of the situation
- In our example, the procurer uses a financial interest rate of \( i=0.12\% \) per month (1.44%/year) to calculate their discount factor
- Discounting choices
  - The lower the discount rate, the greater value placed on the future
    - e.g. social policy vs private investment in capital (7-12%)
## Time – Flowsheet for Valuing Future Costs and Benefits

<table>
<thead>
<tr>
<th>Months from Present</th>
<th>Value</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs (R&amp;D)</td>
<td>1,000,000</td>
<td>-</td>
<td>-</td>
<td>200,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Costs (Price)</td>
<td>100,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Benefit (Savings - cost reduction)</td>
<td>2,425,500</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Discount factor</td>
<td>Present Value</td>
<td>0.99880</td>
<td>0.99760</td>
<td>0.99641</td>
<td>0.99521</td>
<td>0.99402</td>
<td>0.99283</td>
<td>0.99164</td>
<td>0.99045</td>
<td>0.98926</td>
</tr>
<tr>
<td>Costs (R&amp;D discounted)</td>
<td>985,383</td>
<td>-</td>
<td>-</td>
<td>199,282</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Costs (Price discounted)</td>
<td>97,163</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Benefit (Savings - cost reduction discounted)</td>
<td>2,290,147</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

![Diagram](image)

Now $\text{\$} \rightarrow \% \rightarrow \% \rightarrow \% \rightarrow \text{Future $\text{\$}} \rightarrow \text{Future $\text{\$}} \rightarrow \text{Future $\text{\$}} \rightarrow \text{Future $\text{\$}}
Calculating Net Present Value

- **Present value** – the sum of discounted cash flows
  - PV(Costs) and PV(Benefits)
- Since we are using expected (vs real) benefits and costs, we use \( PV(EC) \) and \( PV(EB) \)

\[
NPV = PV(EB) - PV(EC)
\]

- The procurer wants to know if the project is worth considering – if its NPV is positive (>0)
  \[
  NPV = PV(EB) - PV(EC) > 0
  \]
- This is equivalent to the benefits being greater than the costs (hence, Cost-Benefit Analysis)
  \[
  PV(EB) > PV(EC)
  \]
Calculating Present Value of Expected Benefits

- Compared with costs, benefits are received over a number of months
- We need to add up the discounted expected benefits over each month

\[
P(V(B)) = \begin{cases} 
B \ast (\delta^V_1 + \delta^V_1 + \delta^V_1 + \ldots \delta^V_2) = \sum_{t=V_1}^{V_2} \frac{B}{(1 + i)^t} & \text{with probability } q \\
0 & \text{with probability } 1 - q
\end{cases}
\]

\[
PV(EB) = q \ast \sum_{t=V_1}^{V_2} \frac{B}{(1 + i)^t}
\]

- Where B are the benefits, V1 is the first month that the solution is implemented, and V2 is the last
- In our example, the solution is implemented from month 24 until month 72 from the beginning of the PCP. The PV(EB) is therefore € 941.662.

\[
PV(EB) = 0.42 \ast (\sum_{t=24}^{72} \frac{49.500}{(1 + 0.0012)^t} \cdot \sum_{t=1}^{24} \frac{49.500}{(1 + 0.0012)^t}) \\
= 0.42 \ast (3.412.415 - 1.170.364) \\
= 941.662
\]
Calculating Present Value of Expected Costs

- While the PV(EB) occur over a period of time, PV(EC) occur at discrete points in time.
- We calculate PV(EB) by inputting values for:
  - costs of phase S (1, 2, and 3)
  - month M (1, 2, and 3) when the phase ends
  - probabilities of success (q1, q2, q3) at each phase

\[
 PV(C) = \left( \frac{s_1}{(1+i)^M_1} + \frac{s_2}{(1+i)^M_2} + \frac{s_3}{(1+i)^M_3} \right) + P \\
\quad \text{with probability (1 – q1)} \\
\quad \text{with probability q1 * (1 – q2)} \\
\quad \text{with probability (q1 * q2) – (q1 * q2 * q3)} \\
\quad \text{with probability q}
\]
Calculating Present Value of Expected Costs

- The PV(EC) is a long calculation:

\[ \text{PV (EC)} = \frac{200.000}{(1 + 0.0012)^3} (1 - 0.7) \]

\[ + \left( \frac{200.000}{(1 + 0.0012)^3} + \frac{300.000}{(1 + 0.0012)^6} \right) (0.7 \times (1 - 0.75)) \]

\[ + \left( \frac{200.000}{(1 + 0.0012)^3} + \frac{300.000}{(1 + 0.0012)^6} + \frac{500.000}{(1 + 0.0012)^9} \right) ((0.7 \times 0.75) - (0.7 \times 0.75 \times 0.8)) \]

\[ + \left( \frac{200.000}{(1 + 0.0012)^3} + \frac{300.000}{(1 + 0.0012)^6} + \frac{500.000}{(1 + 0.0012)^9} + 100.000 \right) (0.42)\]

- That is made easier by the use of Excel

- In our example, the PV(EC) of the PCP is €722.092
Net Present Value
– comparing $PV(CE)$ and $PV(EB)$

- The procurer should invest in the PCP and PPI if the NPV is positive, that is, $PV(EB) > PV(EC)$

\[
q \times \sum_{t=V_1}^{V_2} \frac{B}{(1 + i)^t} > \frac{s_1}{(1+i)^M_1} (1 - q_1) \\
+ \left( \frac{s_1}{(1+i)^{M_1}} + \frac{s_2}{(1+i)^{M_2}} \right) (q_1 \times (1 - q_2)) \\
+ \left( \frac{s_1}{(1+i)^{M_1}} + \frac{s_2}{(1+i)^{M_2}} + \frac{s_3}{(1+i)^{M_3}} \right) ((q_1 \times q_2) - (q_1 \times q_2 \times q_3)) \\
+ \left( \frac{s_1}{(1+i)^{M_1}} + \frac{s_2}{(1+i)^{M_2}} + \frac{s_3}{(1+i)^{M_3}} + P \right) (q)
\]
Calculating break-even time

- Knowing the equation where \( PV(EB) > PV(EC) \), we can solve for different values that help us to better understand the potential project.
- You can only solve for one unknown at a time.
  - This means choosing which value to find a minimum or maximum for, and making it the dependent variable. Your input values are the independent variables.
- In this example, we will solve for the time it takes for the investment to break even - the number of months in the future where the costs = benefits.
- Using the spreadsheet, we find that this is just over 39 months from project inception, equaling a minimum implementation time of 15 months.

<table>
<thead>
<tr>
<th>PV expected cash flows</th>
<th>€</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs PCP</td>
<td>722,092</td>
</tr>
<tr>
<td>Costs PPI</td>
<td>40,808</td>
</tr>
<tr>
<td>Benefits Savings</td>
<td>722,107</td>
</tr>
<tr>
<td>Net</td>
<td>15</td>
</tr>
</tbody>
</table>

Enter number of months in cell B83 that make cell B80 is just greater than 0. This is the break-even point in months from project inception.  
\[ t \ (\text{number of months from beginning}) \quad 39.16 \]
Calculating Return on Investment (ROI)

- The **Return On Investment (ROI)** expresses how many additional euros are generated by a single euro invested in the PCP project.

- If \( ROI > i \) then, from a purely financial point of view, investing the money in a PCP would be more profitable than in market activities.

\[
ROI = \frac{PV(EB) - PV(EC)}{PV(EC)} = \frac{NPV}{PV(EC)}
\]

\[
ROI = \frac{941,662 - 722,092}{722,092} = \frac{219,570}{722,092} = 30,41\%
\]
Calculating Internal Rate of Return (IRR)

- The **Internal Rate of Return (IRR)** is the minimum rate $i$ needed to make the NPV positive.
- Using Excel makes this task much simpler.
- In this example, the IRR is 0.5172%/month, or 6.2%/year.
- Supports that PCP can be profitable even for costly R&D with uncertainties.

<table>
<thead>
<tr>
<th>PV expected cash flows</th>
<th>Solving for IRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>€</td>
<td></td>
</tr>
<tr>
<td>Costs PCP 690,650</td>
<td>€</td>
</tr>
<tr>
<td>Costs PPI 88,355</td>
<td>€</td>
</tr>
<tr>
<td>Benefits Savings 779,015</td>
<td>€</td>
</tr>
<tr>
<td>Net 10</td>
<td>€</td>
</tr>
</tbody>
</table>

Enter the interest rate in cell B65 that makes cell B61 just greater than 0. This the interest rate that makes $PV(EC) = PV(EB)$, and is equal to the Internal Rate of Return (IRR).

| Alternative interest rate (%) | 0.5172 |

IRR is this many times greater than market interest rate in cell B27.
The Stand-Alone PPI
Calculating NPV of only a Public Procurement of Innovation (PPI)

- A PPI is simpler to calculate, since there is much less uncertainty without R&D
- At this point, we assume the risk of failing to develop the product is eliminated
  - Future benefits are no longer termed expected, but real
- The cost for the procurer in a PPI is the purchasing price
  - Now, costs are given now only by the purchasing price, such that $C = P$.
- The present value (PV) of all future benefits would now be
  \[ PV(B) = B(\delta^t + \delta^{t+1} + \delta^{t+2} \ldots \delta^X) = \sum_{t=1}^{X} \frac{B}{(1 + i)^t} \]
- Where $X$ is the last month in which the solution is implemented, $B$ is the monthly benefit, and $t$ is the month

\[ NPV = \left( \sum_{t=1}^{X} \frac{B}{(1 + i)^t} \right) - C \]
Calculating NPV of only a Public Procurement of Innovation (PPI) (cont.)

- The formula for NPV is given by
  
  \[ NPV = \left( \sum_{t=1}^{X} \frac{B}{(1+i)^t} \right) - C \]

- Using the values from our example, with timespan of the PPI project \( t = X = 48 \), we get calculate the NPV of our project as
  
  \[ NPV = \left( \sum_{t=1}^{48} \frac{49.500}{(1+0.0012)^t} \right) - 100.000 = 679.015 \text{€} \]

- If we want to find the maximum price to pay for the product, we can set the NPV to 0 and solving for \( P \) instead of setting the price at 100.000€.
  
  \[ P \leq \sum_{t=1}^{48} \frac{49.500}{(1+0.0012)^t} = 779.015 \text{€} \]

- Remember that this price is includes discounting. To bring it back to current euro, as what we would invest at the present time, we can use the PV function in excel. This is equal to 735.437€.
Sharing Profits: Royalty Schemes
Reducing Costs of R&D Investments

- Procurers have two options to reduce the costs of their PCP investments
  - Ex-ante: setting maximum costs and awarding based on submitted R&D prices
  - Ex-post: creating profit sharing agreements as royalty schemes
- Intellectual Property Rights (IPR) can be generated during any PCP phase
- Not all suppliers who create IPR will
  - Commercialize their solutions
  - Win the PPI
  - Generate profits in wider markets
- If the IPR is left with the supplier, a procurer pays pay for part of this IPR without being certain of receiving benefits from the investment
Profit Sharing Agreements

- Assumption: IPR stays with the supplier, grants free license; Supplier is responsible for commercializing PCP outcomes
- To capture benefits from IPR generated during the PCP, when IPR is left with the supplier, a procurer can use a profit sharing agreement.
- Procurer takes a % of profits (royalties) post-commercialization
- Agreements made prior to beginning each phase with each R&D supplier
  - Procurer can benefit from their investment regardless of which supplier is dropped from the competition and when
- Two areas for the business case:
  - For each PCP stage: Contributions of the procurer and supplier to R&D
  - After the completion of the PCP: Break-even time
Minimum number of suppliers to ensure competition in PCP:

- Phase 1: Budget per phase EUR 100,000
- Phase 2: Budget per phase EUR 200,000
- Phase 3: Budget per phase EUR 300,000

Budget per supplier per phase:
- EUR 25,000
- EUR 66,667
- EUR 150,000

Profit-sharing agreements:
- Needs assessment & Business case
- Phase 1: Solution design
- Phase 2: Prototype development
- Phase 3: First batch development
Choosing & Using Royalty Rates

- Royalties: a \textbf{percentage of the profit} based on investment in IPR
- Royalties should be taken only when the supplier begins to make a profit
- Which royalty rate the procurer should set for each supplier within each stage of a given PCP?
  - $G_{i,j}$ - cost of PCP to the procurer in PCP phase $i$ to supplier $j$
  - $H_{i,j}$ - contribution of supplier $j$ during PCP phase $i$
  - $N_{i,j}$ - percent of profit (royalties) requested by per month from supplier $j$
- The royalty rate for supplier $j$ who participates in PCP phase $i$ is then

$$N_{i,j} = \frac{G_{i,j}}{(G_{i,j} + H_{i,j})}$$
Calculating a Royalty Rate – Example

- A procurer has a budget of €100,000 for phase 1, for four suppliers
- Each supplier receives €25,000
  - For supplier 1 we write $G_{1,1} = €25,000$
- Assume that this is 20% of the total R&D costs, so that contribution by each supplier in phase 1 will be €125,000 (€25,000/.2)
  - For supplier 1, we write $H_{1,1} = €125,000$
- This means that royalty rate for supplier number 1 for PCP phase 1 are

  \[
  N_{1,1} = \frac{G_{1,1}}{(G_{1,1} + H_{1,1})} = \frac{25,000}{25,000 + 125,000} = .17 = 17\%.
  \]

- Repeat for each phase and supplier
Calculating Royalty Rates for Each Supplier & Phase – Example

- Royalty rate for supplier 1 would increase to 23% for IPR from phase 2, and to 29% for IPR from phase 3.

<table>
<thead>
<tr>
<th>Project Stage</th>
<th>Phase Duration (months)</th>
<th>PCP budget, per phase</th>
<th>Number of Suppliers, per phase</th>
<th>Budget per Supplier, per phase</th>
<th>% of Total Costs Contributed by Procurer, per phase</th>
<th>Contribution by Supplier (Supplier R&amp;D Costs), per phase</th>
<th>Royalty rate, per supplier and phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCP phase 1</td>
<td>3</td>
<td>€ 100,000</td>
<td>4</td>
<td>€ 25,000</td>
<td>20%</td>
<td>€ 125,000</td>
<td>17%</td>
</tr>
<tr>
<td>PCP phase 2</td>
<td>6</td>
<td>€ 200,000</td>
<td>3</td>
<td>€ 66,667</td>
<td>30%</td>
<td>€ 222,222</td>
<td>23%</td>
</tr>
<tr>
<td>PCP phase 3</td>
<td>9</td>
<td>€ 300,000</td>
<td>2</td>
<td>€ 150,000</td>
<td>40%</td>
<td>€ 375,000</td>
<td>29%</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>€ 600,000</td>
<td></td>
<td>€ 241,667</td>
<td></td>
<td>€ 722,222</td>
<td></td>
</tr>
</tbody>
</table>
Calculating Break-even Time for Royalty Agreements

- After each phase of the PCP is complete, a royalty agreement can come into effect
- Now we are examining the situation after the completion of the PCP
  - Costs are not R&D costs contributed by suppliers in the PCP, but all other costs: costs of commercialization, production, marketing, offices, staff…
- Introducing
  - $p$ - probability of successful commercialization of any supplier involved at any stage of the PCP – that includes any IPR generated under the PCP
  - $P_{i,j}$ - monthly profit of supplier $j$ who has successfully commercialized using IPR from PCP phase $i$
    - $P_{i,j} = R_{i,j} - C_{i,j}$, (profits are revenues minus costs)
  - $Q_{i,j}$ - total royalties received by the procurer by time $t$ from supplier $j$ based on their successful commercialization using IPR from PCP phase $i$
Calculating Break-even Time for Royalty Agreements

- **Expected benefits to the procurer**, given the probability of successful commercialization \( p \)
- For **each** supplier \( j \) at PCP phase \( i \), the expected benefits \( EB_{i,j} \) can be expressed as:

\[
P V(E B_{i,j}) = Q_{i,j} = \begin{cases} 
  p \cdot N_{i,j} \cdot (\delta^{M_i} + \delta^{M_i+1} + \delta^{M_i+2} ... \delta^{Y_{i,j}}) = p \cdot N_{i,j} \sum_{t=M_i}^{Y_{i,j}} \frac{R_{i,j} - C_{i,j}}{(1 + r)^t} & \text{when } R_{i,j} > C_{i,j} \\
  0 & \text{when } R_{i,j} \leq C_{i,j} 
\end{cases}
\]

- \( M_i \) - the first time \( t \) where \( R_{i,j} > C_{i,j} \),
- \( Y_{i,j} \) - the time \( t \) where \( Q_{i,j} = G_{i,j} \) (where total royalties received from supplier \( j \) in PCP phase \( i \) are equal to the procurer’s investment to supplier \( j \) in PCP phase \( i \))
Calculating Break-even Time for Royalty Agreements

- Royalties are only at a given time $t$ when $R_{i,j} > C_{i,j}$
- **Break-even time** for each investment $C_{i,j}$ to each is the point in time after which $Q_{i,j} = C_{i,j}$
- Present Value of **total** Expected Benefits
  \[ PV(EB) = p \ast \sum Q_{i,j} \quad \forall \ i, j \]

- Note: Procurers **do not make a profit themselves**
  - Benefit from the results of the solution which followed the PCP in a successful PPI
  - Stop at the break-even time
Calculating Break Even Time – Example

- One supplier who reached the end of PCP phase 3 takes 6 months to commercialize the results of the IPR they generated.
- Commercialization and production costs €450,000, with a 70% likelihood of success.
- Firm operates at a loss for 8 months.
- Profit begins from month 9, at €20,000 every month (for at least 40 months into the future).

<table>
<thead>
<tr>
<th>Project Stage</th>
<th>Phase Duration (months)</th>
<th>Revenue or Expense (to the supplier)</th>
<th>Frequency</th>
<th>Commercialization Success probability (general)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercialization/Production</td>
<td>6</td>
<td>€450,000</td>
<td>(one-time)</td>
<td>70%</td>
</tr>
<tr>
<td>Months of Loss</td>
<td>8</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Months of Profit</td>
<td>40</td>
<td>€20,000</td>
<td>(monthly)</td>
<td></td>
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<tr>
<td>Month when profit begins</td>
<td>32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest Rate (Monthly)</td>
<td>0.12%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Calculating Break Even Time – Example

|PCP Phase 1|  
|---|---|---|
|Present Value of Expected Benefits (€)| 25,188| 25,000|

Enter number of months below that makes the above cell just greater than the procurer’s investment to the supplier in phase 1.

This is the number of months in which royalties will be received from this supplier for IPR generated in phase 1.

Months to collect royalties: 11.3

- Repeat for each phase completed by the supplier
Break Even Time – Example

Number of months of royalty payments required to recover procurer PCP costs, per phase

- PCP phase 3
- PCP phase 2
- PCP phase 1
Summary
Uncertainty is introduced as a probability – a factor between 0 and 1 that reflects the likelihood that something will occur.

- Success of each PCP phase
- Successful commercialization
- Receiving expected market revenues

More information = better estimates

- Importance of market consultation

Due to uncertainty, a 3-phase PCP is always better than all in one stage

- Probability of complete loss is lower
- Return on Investment (ROI) is higher

\[ ROI = \frac{Benefits - Costs}{Costs} \]
Summary – Time & Returns

- Valuing costs and benefits in the future is done by using a (carefully selected) discount rate
  - Calculate cash flows over multiple months by using indefinite summation (∑)
  - Cash flows at one time are more suited to examining probability

- Measures of project profitability
  - Net Present Value (NPV) – to predict project profitability
    \[ NPV = \text{Present Value (Expected Benefits)} - \text{Present Value (Expected Costs)} \]
  - Internal Rate of Return (IRR) – rate of return from an investment
    - Alternative discount rate \( i \) that makes the NPV=0
  - Return on Investment (ROI) – investment gains compared with investment costs
    \[ ROI = \frac{\text{Benefits} - \text{Costs}}{\text{Costs}} \]
Summary – Finding Max’s & Min’s

Once you have the basic formula

\[ \text{NPV} = \text{Present Value (Expected Benefits)} - \text{Present Value (Expected Costs)} \]

You can calculate maximum/minimums for any value by finding what makes \( \text{Benefits} = \text{Costs} \)

1. Choose one variable to be dependent
2. Set values for the other independent variables
3. Solve using a program like Excel

This can tell the procurer

- The minimum time over which they should implement a PPI solution
- Minimum success probabilities, minimum R&D revenues, etc. etc.

We solved for the break-even time \( t \)
Profit sharing can make PCP a more attractive investment for procurers

- Helps compensate for high up-front costs
- A procurer can calculate revenue sharing based on predictions of wider market revenues
- Influence of commercialization risk / probability of commercial success
- Investment risk and potential rewards (royalties) are spread over suppliers and phases
Summary

- Introduction to procurement economics
- Innovation procurement
  - Pre-commercial Procurement (PCP)
  - Public Procurement of Innovative Solutions (PPI)
- Introduction to the Business Case Methodology
- Economic evaluation – theory and practice
  - Uncertainty - Justifying PCP
  - Time - Discounting, Net Present Value, Returns
  - The stand-alone PPI
  - Reaping rewards – Royalty Schemes
- Discussion
Thank you!
Discussion
Annex
## PCP vs PPI

<table>
<thead>
<tr>
<th></th>
<th>PCP</th>
<th>PPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>When</td>
<td>Challenges requires R&amp;D</td>
<td>Challenge requires (near-to-market) solution; No R&amp;D</td>
</tr>
<tr>
<td></td>
<td>No commitment to PPI</td>
<td></td>
</tr>
<tr>
<td>What</td>
<td>Purchase of R&amp;D to steer development, inform</td>
<td>Procurer is launching customer / early adopter / first</td>
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<td></td>
<td>alternatives, &amp; avoid lock-in</td>
<td>buyer</td>
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<tr>
<td>How</td>
<td>Purchase of R&amp;D from several suppliers in</td>
<td>Buy critical mass of innovative solutions to trigger</td>
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<td>parallel</td>
<td>industry</td>
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</table>