Uncertainty in Competitive Bidding – Supporting Pricing Decision with Probabilistic Models

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Outline

• Introduction
• Aim and methodology
• Uncertainty framework for competitive bidding
• Validation
• Future work
Introduction

- **Servitisation** – move from selling products to offering services
- **Product-centred services**
• To support **pricing decisions** at the competitive bidding stage for service contracts
• Model **uncertainty** to support the decision-making process

• **What price to bid?**
  – Probability of winning the contract
  – Probability of making a profit
Research methodology

Observation

- Participants from industry,
- Experimental studies with questionnaires:
  - SCAF workshops
  - 83 participants from defence and aerospace sectors
  - Influences of different bidding situations and input information

Theory

- Interview study:
  - 9 participants
  - Additional industrial sectors, e.g. construction

Validation

Implementation
Theory - Uncertainty framework

Service contract conditions
- Service requirements
- Product performance
- Market and economy incl. legal requirements

Internal company processes
- Service design for fulfilling service requirements
- Cost estimate
- Expanded contract portfolio over contract period

Bidding strategy

Customer
- Budget limitations
- Evaluation criteria of the competitive contract bids
- Possible future needs

Competitors
- Competitors’ identities
- Their cost estimates
- Their available technologies and knowledge
- Their experience with similar services
Capability to rescue trapped miners

Two systems:
- Investigation
- Rescue

- 10 year contract
Validation – Probabilistic models

- Service contract conditions
  - Service requirements
  - Product performance
  - Market and economy incl. legal requirements

- Internal company processes
  - Service design for fulfilling service requirements
  - Cost estimate
  - Expanded contract portfolio over contract period

- Bidding strategy

- Customer
  - Budget limitations
  - Evaluation criteria of the competitive contract bids
  - Possible future needs

- Competitors
  - Competitors’ identities
  - Their cost estimates
  - Their available technologies and knowledge
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Probability of making a profit
Probability of winning the contract
Case study – Probabilistic models

Customer
- Budget limitations
- Evaluation criteria of the competitive contract bids
- Possible future needs

Competitors
- Competitors’ identities
- Their cost estimates
- Available technologies and knowledge
- Experience with similar services

Probability of acceptance

Probability of being lead bidder

Probability of winning

Probability of making a profit

Internal company processes
- Service design for fulfilling service requirements
- Cost estimate
- Expanded contract portfolio over contract period
Case study – Probability of acceptance

Customer – Probability of acceptance

• Budget limitations: £40M

\[
P_{\text{acceptance}} = \begin{cases} 
1 & \text{for } p \leq 40 \\
2 - 0.025 \cdot p & \text{for } 40 < p \leq 42 \\
15.65 - 0.35 \cdot p & \text{for } 42 < p \leq 44 \\
2.45 - 0.05 \cdot p & \text{for } 44 < p \leq 48 
\end{cases}
\]

Van der Gaag et. al, 1999
Competitor A: likely cost to be £1-2M > Bidding Company, confidence: 50%

\[ c_A = £40.95M + £[1, 2]M = £[41.95, 42.95]M \]

+ Profit 12.31%: £[5.16, 5.29]M

= Price value: £[47.11, 48.24]M

\[
P(p < p_A) = \begin{cases} 
[0.75, 1] & \text{for } p \leq 47.11 \\
[0.25, 0.75] & \text{for } 47.11 < p \leq 48.24 \\
[0, 0.25] & \text{for } p > 48.24 
\end{cases}
\]
Probability of being lead bidder

- Four competitors

\[ P_{\text{lead}} = P(p < p_A) \cdot P(p < p_B) \cdot P(p < p_C) \cdot P(p < p_D) \]
Case study – Probability of winning

**Probability of winning**:  
\[ P_{\text{winning}} = 0.8 \cdot P_{\text{acceptance}} + 0.2 \cdot P_{\text{lead}} \]

Weight = 0.8

Weight = 0.2

![Diagram showing the probability of winning with a graph indicating probability values at different price levels.](image-url)
Case study – Probability of making a profit

\[ P_{\text{profit}} = P(p>c_a) \]

Cost estimate (£40.95M) with 70% confidence value

+ Risk allowance of £1M

\[ P_{\text{profit}} = \begin{cases} 
[0, 0.15] & \text{for } p < 40.95 \\
[0.15] & \text{for } p = 40.95 \\
[0.15, 0.85] & \text{for } 40.95 < p \leq 41.95 \\
[0.85, 1] & \text{for } p > 41.95 
\end{cases} \]

Decision Matrix

<table>
<thead>
<tr>
<th>Price bids [£M]</th>
<th>40</th>
<th>41</th>
<th>42</th>
<th>43</th>
<th>44</th>
<th>45</th>
<th>46</th>
<th>47</th>
<th>48</th>
</tr>
</thead>
<tbody>
<tr>
<td>( P_{\text{winning}} )</td>
<td>86-100%</td>
<td>84-98%</td>
<td>82-96%</td>
<td>54-68%</td>
<td>21-37%</td>
<td>16-26%</td>
<td>12-15%</td>
<td>8-11%</td>
<td>4%</td>
</tr>
<tr>
<td>( P_{\text{profit}} )</td>
<td>0%</td>
<td>15-85%</td>
<td>85-100%</td>
<td>85-100%</td>
<td>85-100%</td>
<td>85-100%</td>
<td>85-100%</td>
<td>85-100%</td>
<td>85-100%</td>
</tr>
</tbody>
</table>
Future work

- Collection of further case studies
- Knowledge transfer
  - Workbooks
  - Workshops (UK and International)
Thank you for your attention.

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Validation – Case study 2

Provision of land vehicles

<table>
<thead>
<tr>
<th>Stage 1</th>
<th>Stage 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prototype</td>
<td>Delivery of 85 vehicles</td>
</tr>
</tbody>
</table>

- Probability of winning
- Probability of making a profit
- Estimated profit value
Case study 2 – Probability of winning

Customer – Probability of acceptance
Price and Performance

Stage 1:

\[ P_{\text{Acceptance}} (p) \]

\[ \begin{align*}
\text{Price} [\text{M} ] & \\
\text{1} & \\
\text{0.8} & \\
\text{0.6} & \\
\text{0.4} & \\
\text{0.2} & \\
\text{0} & \\
\end{align*} \]

Stage 2:

\[ P_{\text{Acceptance}} (p) \]

\[ \begin{align*}
\text{Price} [\text{M} ] & \\
\text{1} & \\
\text{0.8} & \\
\text{0.6} & \\
\text{0.4} & \\
\text{0.2} & \\
\text{0} & \\
\end{align*} \]
Case study 2 – Probability of winning

Competitors – Probability of being lead bidder

Competitor A

**Stage 1:** Between $M9.4 and $M10.4

**Stage 2:** Between $M123 and $M137
Case study 2 – Probability of winning

Stage 1:

\[ P_{\text{winning}}(p) = \begin{cases} 
0.5, & p \leq 7 \\
2.5 \cdot p - 17, & 7 < p \leq 7.2 \\
1, & 7.2 < p \leq 8 \\
0.5, & 8 < p \leq 8.03 \\
5.0113 - 0.5618 \cdot p, & 8.03 < p \leq 8.35 \\
(5.0113 - 0.5618 \cdot p) \cdot (10.076 - 1.087 \cdot p), & 8.35 < p \leq 8.92 \\
0, & p > 8.92 
\end{cases} \]

Stage 2:

\[ P_{\text{winning}}(p) = \begin{cases} 
0.5, & p < 98 \\
\frac{1}{2} \cdot p - 24, & 98 \leq p < 100 \\
5.5 - \frac{1}{12} \cdot p, & 100 \leq p < 108 \\
\frac{1}{264} \cdot p^2 - \frac{7}{8} \cdot p + \frac{21}{22}, & 108 \leq p < 110 \\
\frac{1}{264} \cdot p^2 - \frac{11}{12} \cdot p + \frac{71}{132}, & 110 \leq p < 111 \\
\frac{1}{14} \cdot (122 - p), & 111 \leq p < 122 \\
0, & p \geq 122 
\end{cases} \]
Case study 2 – Probability of making a profit

Cost distributions

Stage 1:

Stage 2:
## Case study 2 – Decision Matrix

Base value: most likely cost

Stage 1: $M10

\[ E_{Profit} = p - 10 \]

Stage 2: $M100

\[ E_{Profit} = p - 100 \]

<table>
<thead>
<tr>
<th>P [$M]</th>
<th>7</th>
<th>7.25</th>
<th>7.5</th>
<th>7.75</th>
<th>8</th>
<th>8.25</th>
<th>8.5</th>
<th>8.75</th>
<th>9</th>
<th>9.25</th>
<th>9.5</th>
<th>9.75</th>
<th>10.0</th>
<th>10.25</th>
<th>10.5</th>
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</thead>
<tbody>
<tr>
<td>P Winning</td>
<td>50%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>38%</td>
<td>20%</td>
<td>5%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>P profit</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2%</td>
<td>12%</td>
<td>55%</td>
<td>92%</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E Profit</td>
<td>-3</td>
<td>-2.75</td>
<td>-2.5</td>
<td>-2.25</td>
<td>-2</td>
<td>-1.75</td>
<td>-1.5</td>
<td>-1.25</td>
<td>-1</td>
<td>-0.75</td>
<td>-0.5</td>
<td>-0.25</td>
<td>0</td>
<td>0.25</td>
<td>0.5</td>
</tr>
</tbody>
</table>