Quantitative Software Management

The Impact of Team Size on Software Project Productivity
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Outline

• What is productivity?
• Process overview
  – Static productivity categories
  – Dynamic productivity categories
• Team size and productivity
• Questions?
What is Productivity?

- **Traditional Productivity**: Ratio between cost/effort and units of size (lines of code per staff month, hours per function point)

- **Advantages**
  - Relatively easy to calculate and understand
  - Effective way to compare similar projects or environments

- **Disadvantages**
  - Does not account for impact of different domains/application types
  - Does not account for schedule, team size, or quality constraints
Productivity Categories (Static)

• Determine medians for technical productivity and schedule productivity from project history

• Assign projects to one of four categories
  – Better than median both measures
  – Worse than median both measures
  – Better technical / worse schedule
  – Worse technical / better schedule

• Analyze variables (project size, staffing, quality, etc.) to uncover relationships
Productivity Categories
Process Overview
(Dynamic Productivity Categories)

• Analysis based on validated software projects completed since 2001

• All projects had effort and duration from the beginning of analysis until release into production

• Projects parsed into four productivity groups
  – Better than average for effort and schedule
  – Worse than average for effort and schedule
  – Better than average for effort; worse for schedule
  – Better than average for schedule; worse for effort
Dynamic Productivity Categories

Projects worse than average for schedule

Projects better than average for schedule

Analyse through Implement Duration vs Size
Process Overview

• Projects divided into quartiles based on size

• Within each quartile, the % of each productivity group was calculated for different team sizes

• Observations made for each quartile about the best team sizes for schedule optimization, cost containment, and risk avoidance
Quartile 1
Up to 4004 ESLOC

Team size 3 or less provides best chance of balancing both schedule and cost/effort
Small teams (2 or less) have highest probability of optimizing cost/effort
Quartile 1 Schedule Productivity

Team size between 2 and 4 best for schedule optimized projects
Quartile 1 Observations

- % projects better than average for schedule increases with team size up to a staff of 3-4
- Effort optimized projects decrease with team size: dramatically when team size > 2
- % projects better than average for effort & schedule increases up to 3 then rapidly decreases
- % high cost long schedule projects increases with team size: dramatically when team > 4
Quartile 1 Recommendations

• Staff should be 2 or less if cost/effort is primary project driver

• Staff should be 2 – 4 if schedule is primary project driver

• Staff of 1 – 3 for best balanced probability of success

• Avoid team size > 4: (> 60% chance of being worse than average for schedule and cost/effort). Large teams are counterproductive
Quartile 2
4005 – 8702 ESLOC

Team size of 1 - 3 provides best chance of balancing both schedule and cost/effort
Quartile 2 Effort Productivity

Effort Productivity Distribution: Quartile 2

Team Size

Percentage

Effort optimized projects decrease steadily with team size. Few projects with teams > 4 are cost/effort optimized.
Many different team sizes work with these projects. Large teams can be used effectively where schedule is paramount.
Quartile 2 Observations

- Wide latitude in staffing for better than average projects (for schedule)
- Effort optimization decreases with size: few projects with staff > 4 are effort optimized
- Staff 1 – 3 has best balanced probability of success
- Effort optimized and balanced probabilities very similar to patterns for smaller (Quartile 1) projects
Quartile 2 Recommendations

- Team size \(<= 3\) best for producing better than average project for effort/cost

- Team size \(1 \rightarrow 3\) provides best balanced probability for better than average project for effort & schedule

- Large teams \((> 8)\) can be used effectively to optimize schedule
Team size of 4 or less provides best chance of balancing both schedule and cost/effort. Sharp drop-off with larger teams.
Quartile 3 Effort Productivity

Teams with 4 or less have highest probability of optimizing cost/effort
Quartile 3 Schedule Productivity

Teams with 4 or less have highest probability of optimizing schedule
Quartile 3 Observations

- % projects with better than average effort drops significantly with teams > 4
- % projects with better than average schedule peaks with teams 3 – 4 then drops
- Teams =< 4 have good balanced probability of success
- Teams > 4 have increased chance of being worse than average for cost/effort and schedule
Quartile 3 Recommendations

- Team size 3 – 4 a good fit for these projects
- Smaller teams (< 3) a good fit if schedule pressure permits
- Avoid teams > 4
Quartile 4
> 20647 ESLOC

Balanced probability of success fairly consistent up to a team size of 8
Quartile 4 Effort Productivity

Teams larger than 8 have little chance of optimizing cost/effort
Quartile 4 Schedule Productivity

Little correlation between team size and schedule productivity
Quartile 4 Observations

- Good chance to optimize effort if team size 6 or fewer
- % projects better than average for schedule & effort fairly constant up to staff of 8
- Projects better than average for schedule peaks at staff of 4 – 5
- Significant increase in projects worse than average for schedule & cost/effort with staff > 8
Quartile 4 Recommendations

• Team size of 5 – 6 provides best balanced probability of success

• Projects with staff > 8 have a high chance of not being efficient in either cost/effort or schedule: keep teams small!
## Optimal Team Sizes

<table>
<thead>
<tr>
<th>Quartile</th>
<th>Schedule Optimized</th>
<th>Cost/Effort Optimized</th>
<th>Balanced Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 4004 ESLOC</td>
<td>2 - 4</td>
<td>&lt; 2</td>
<td>1 - 3</td>
</tr>
<tr>
<td>4005 - 8702 ESLOC</td>
<td>2 - 6</td>
<td>1 - 3</td>
<td>1 - 3</td>
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<tr>
<td>8703 - 20647 ESLOC</td>
<td>2 - 4</td>
<td>1 - 4</td>
<td>2 - 4</td>
</tr>
<tr>
<td>20647+ ESLOC</td>
<td>4 - 6</td>
<td>1 - 5</td>
<td>2 - 6</td>
</tr>
<tr>
<td>Large Projects &gt; 70000 ESLOC</td>
<td>10 - 20</td>
<td>10 - 20</td>
<td>10 - 20</td>
</tr>
</tbody>
</table>
Overall Observations

• **Strong relationship between team size and effort efficiency:** Small teams are more productive

• **Relationship between team size and schedule is more tenuous:** Large teams not always associated with faster time to market

• **Smaller teams far less likely to be worse than average for both effort and schedule**
Questions?
Backup Slides
Large Project > 70000 ESLOC

Team size between 10 & 20 stands out as best choice for optimizing both schedule & cost/effort
Very Large Project Observations

• Staffing between 10 & 20 is a sweet spot for both schedule and cost/effort

• Projects with staff > 20 either optimize schedule or are high cost, slow to deliver
Very Large Project Recommendations

- Use a staff between 10 – 20 for optimal performance
- Projects with a staff > 20 are high cost and have a > 50% chance of being slow to deliver, too
Analyze through Implement Effort vs Size

1st Quartile

2nd Quartile

3rd Quartile

4th Quartile

Size (thousands)

Staff Months of Effort

- Business Systems
- Avg. Line Style
- 1 Sigma Line Style