

Quantitative Software Management

The Impact of Team Size on Software Project Productivity

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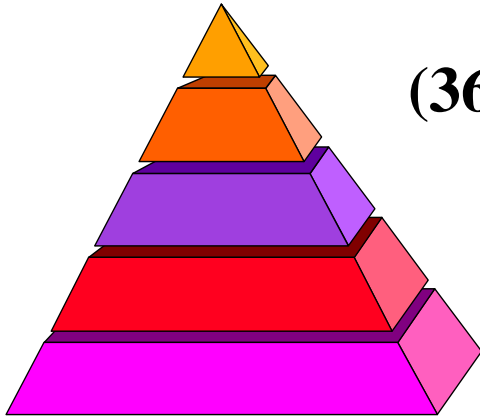
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Outline

- **What is productivity?**
- **Process overview**
 - **Static productivity categories**
 - **Dynamic productivity categories**
- **Team size and productivity**
- **Questions?**

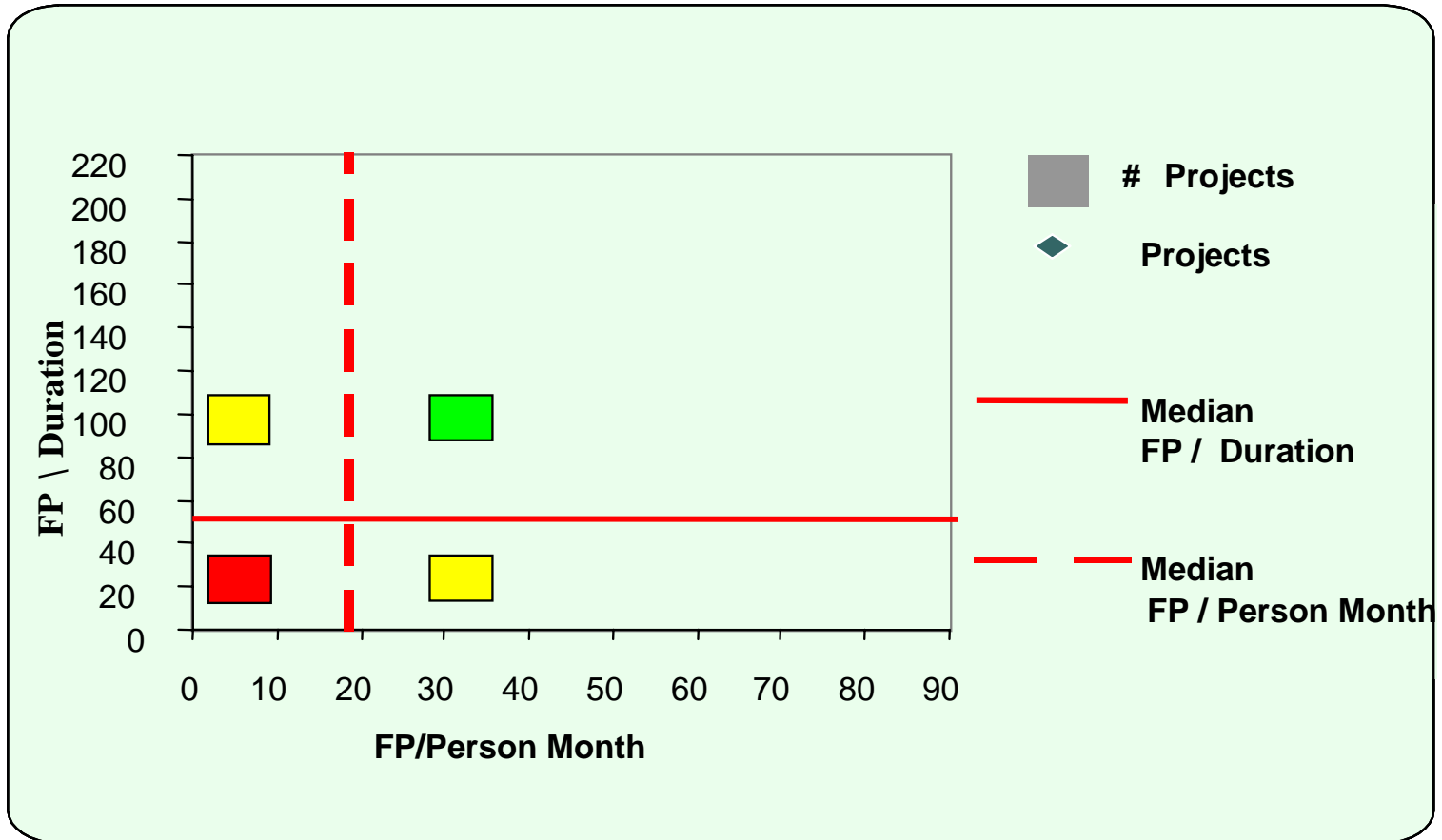
What is Productivity?

- **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

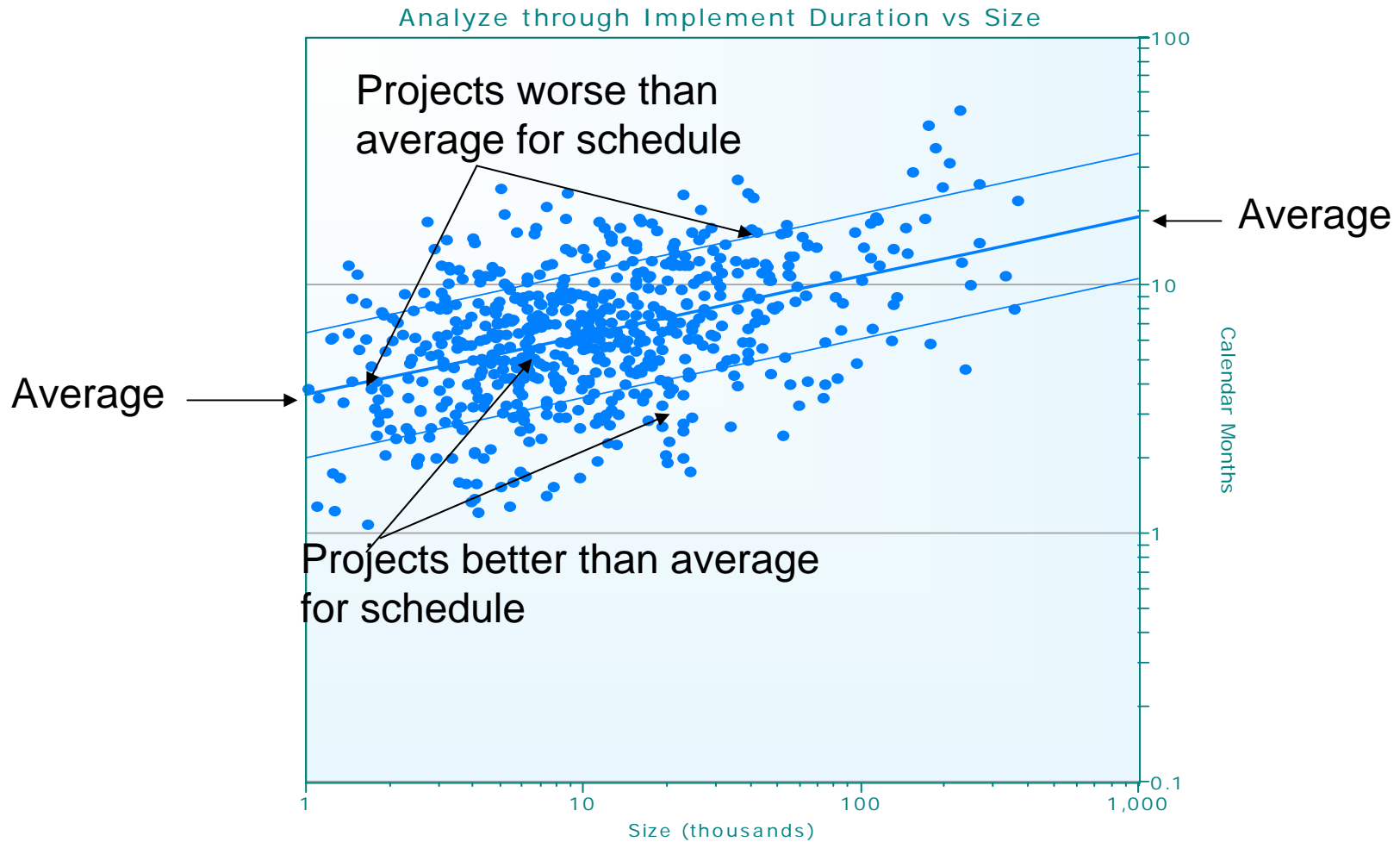


Process Overview

(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**

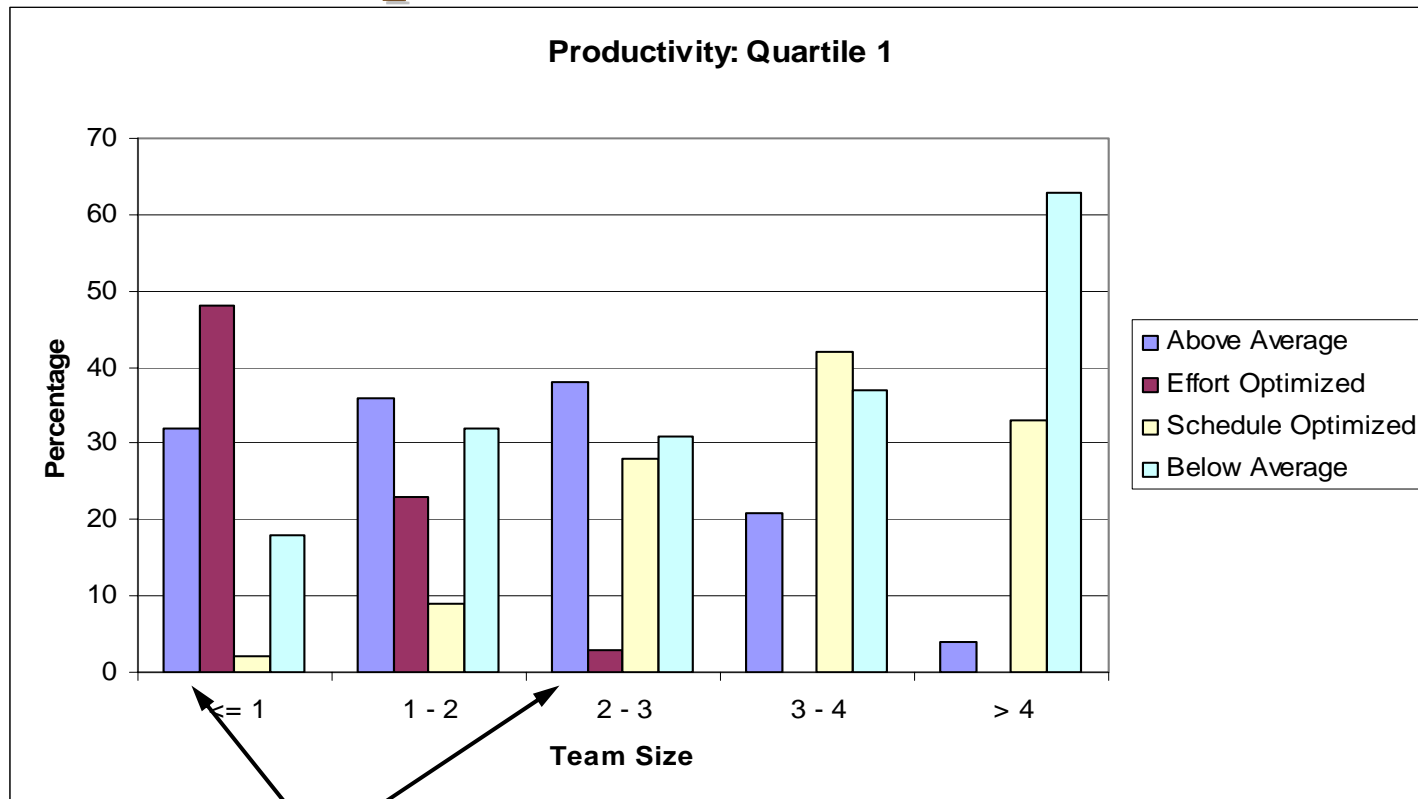
Dynamic Productivity Categories



Process Overview

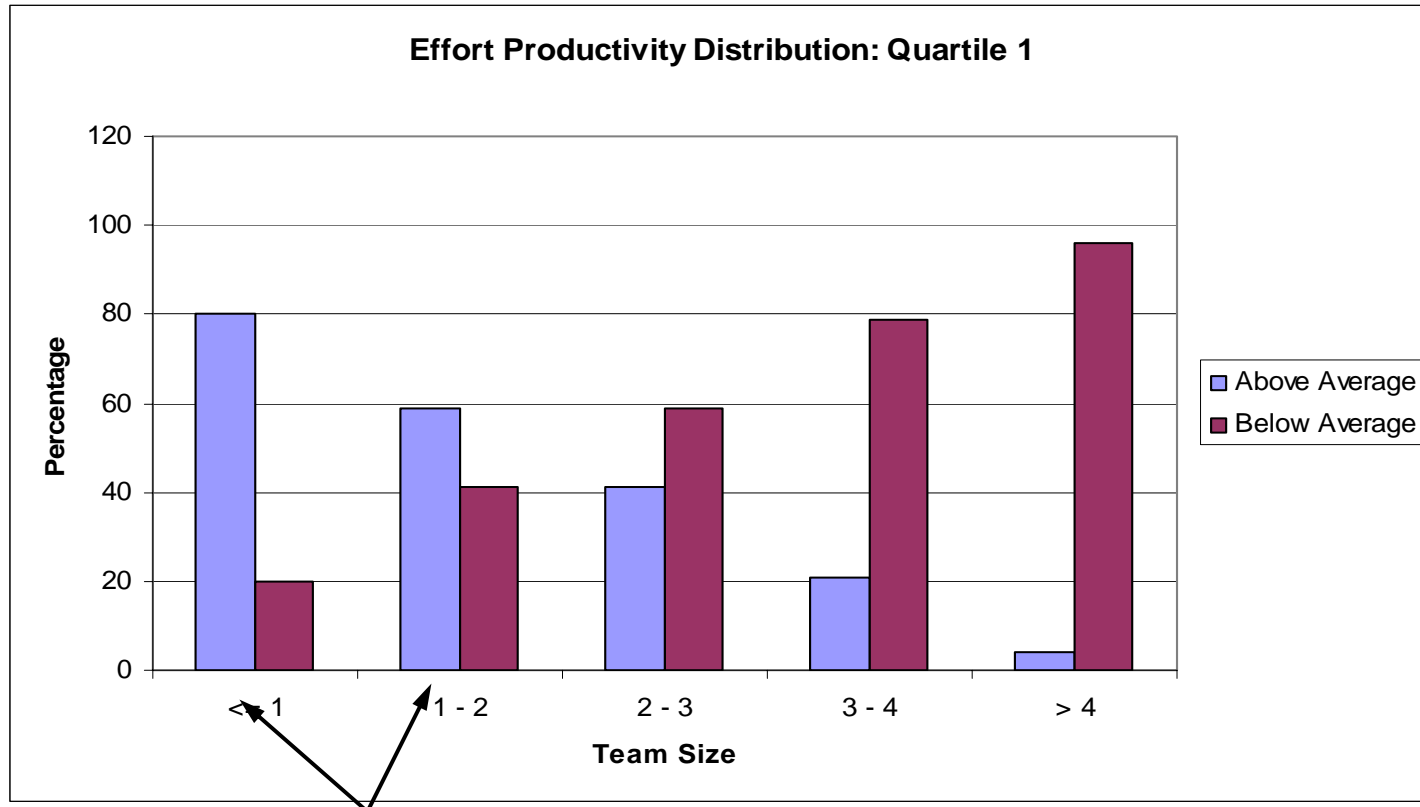
- **Projects divided into quartiles based on size**
- **Within each quartile, the % of each productivity group was calculated for different team sizes**
- **Observations made for each quartile about the best team sizes for schedule optimization, cost containment, and risk avoidance**

Quartile 1 Up to 4004 ESLOC



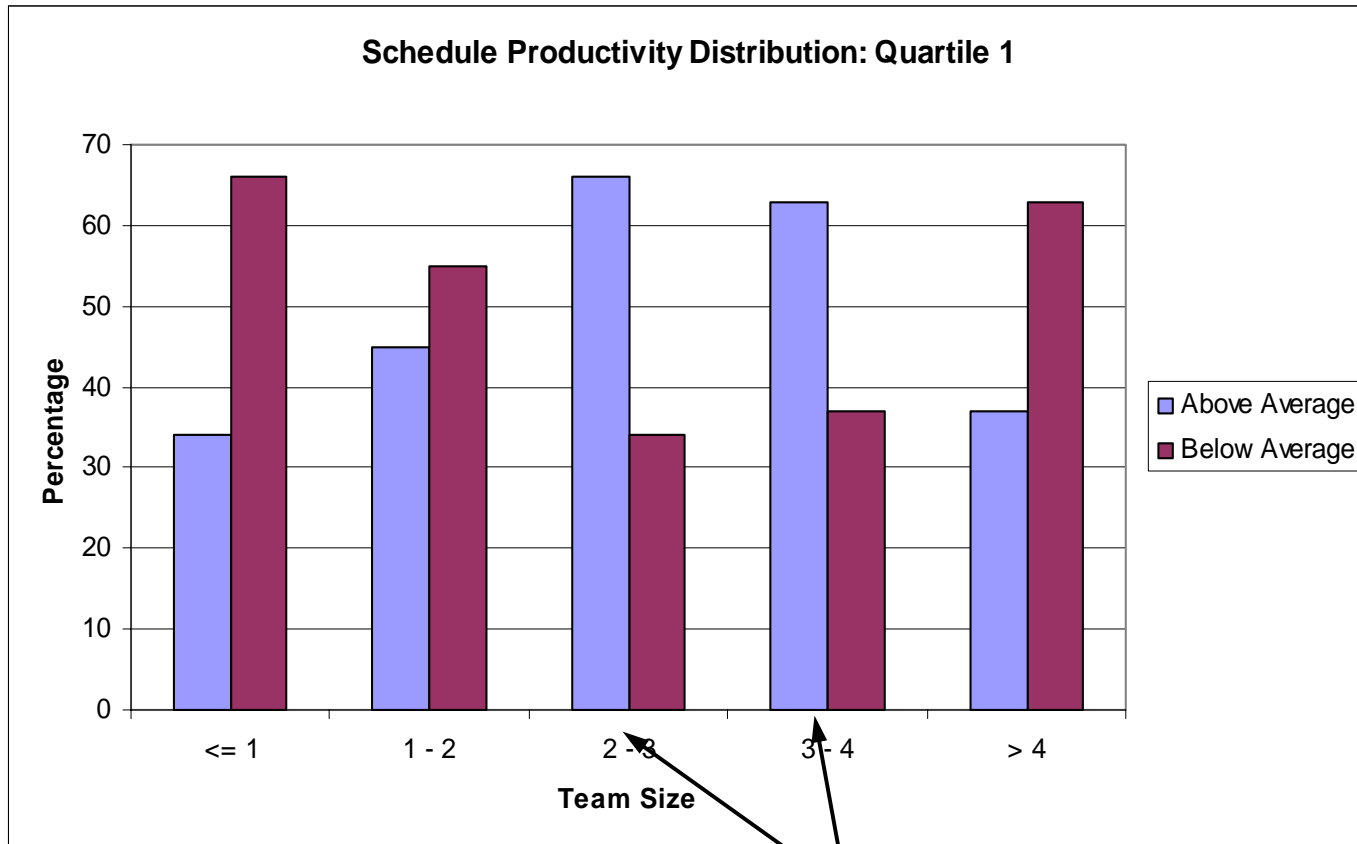
Team size 3 or less provides best chance of balancing both schedule and cost/effort

Quartile 1 Effort Productivity



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

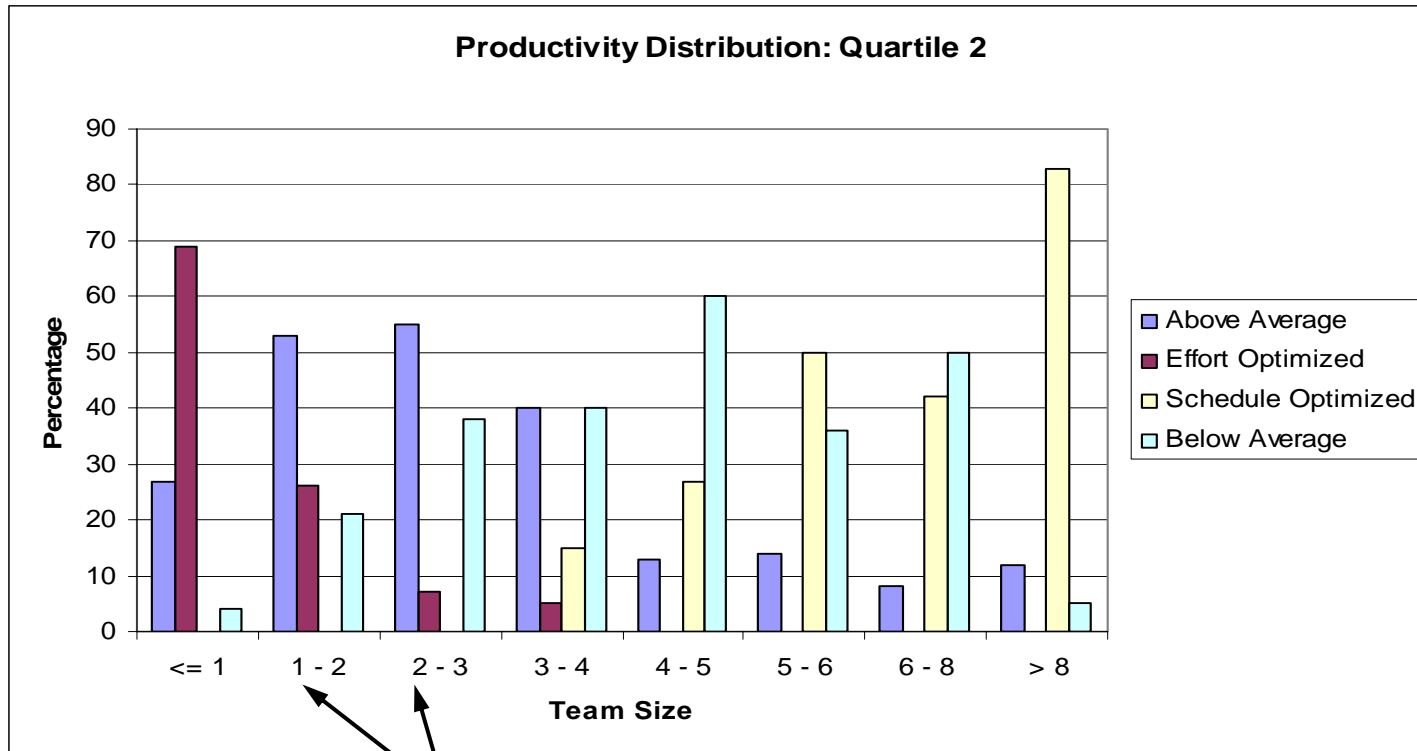
- **% projects better than average for schedule increases with team size up to a staff of 3-4**
- **Effort optimized projects decrease with team size: dramatically when team size > 2**
- **% projects better than average for effort & schedule increases up to 3 then rapidly decreases**
- **% high cost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

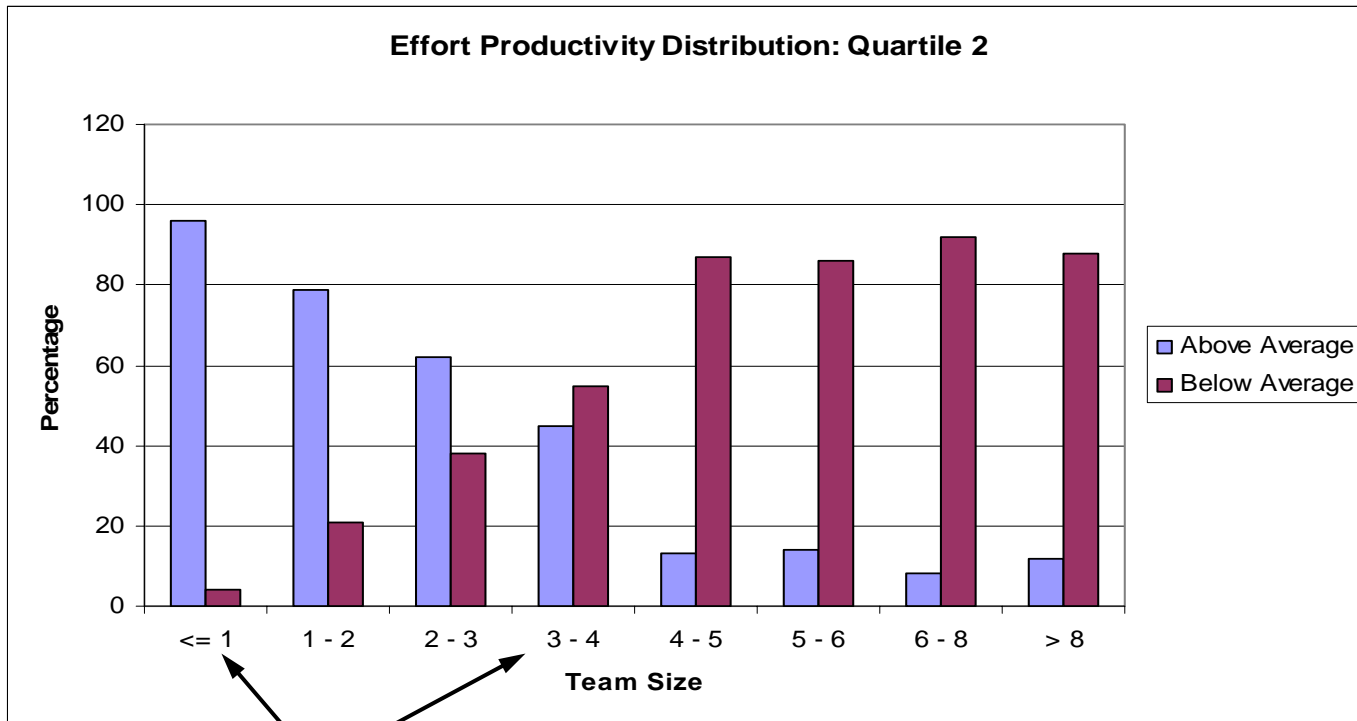
Quartile 2

4005 – 8702 ESLOC



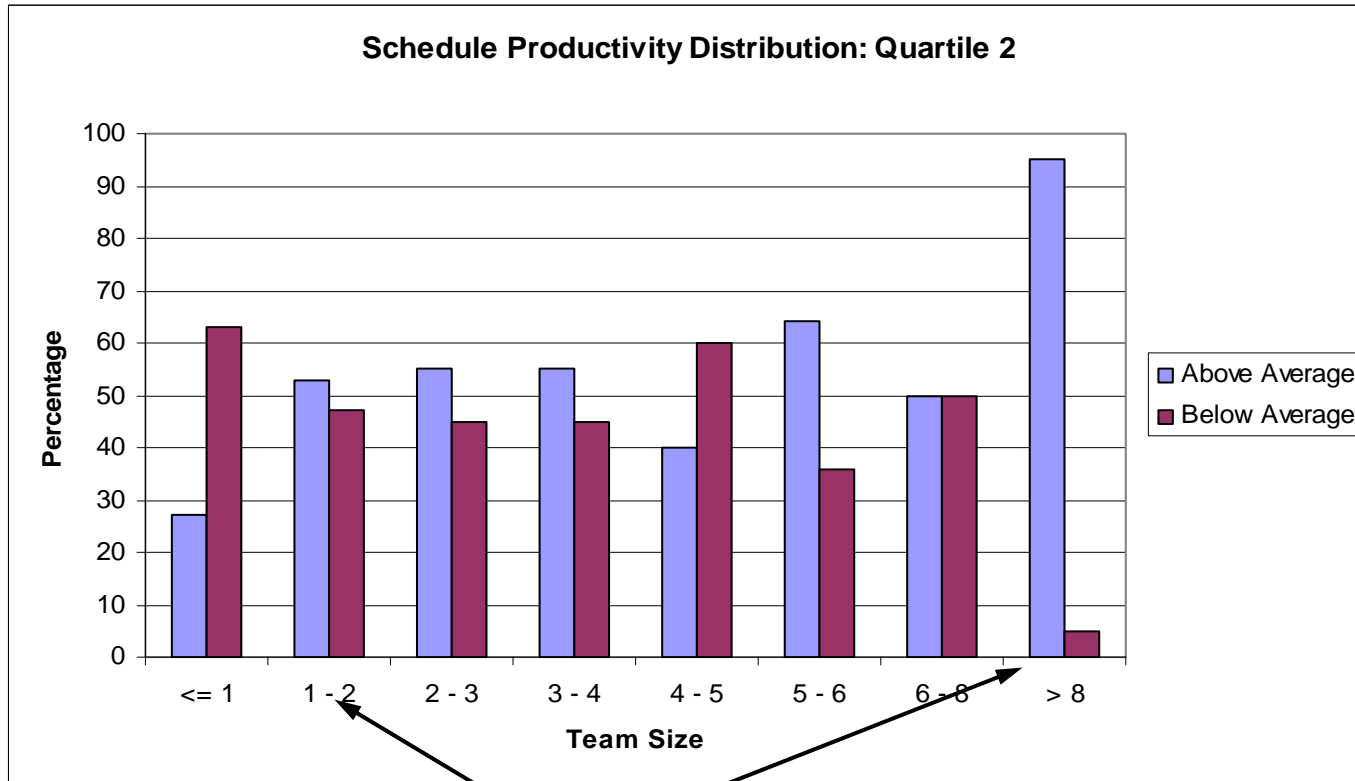
Team size of 1 - 3 provides best chance of balancing both schedule and cost/effort

Quartile 2 Effort Productivity



**Effort optimized projects decrease steadily with team size.
Few projects with teams > 4 are cost/effort optimized**

Quartile 2 Schedule Productivity



Many different team sizes work with these projects. Large teams can be used effectively where schedule is paramount

Quartile 2 Observations

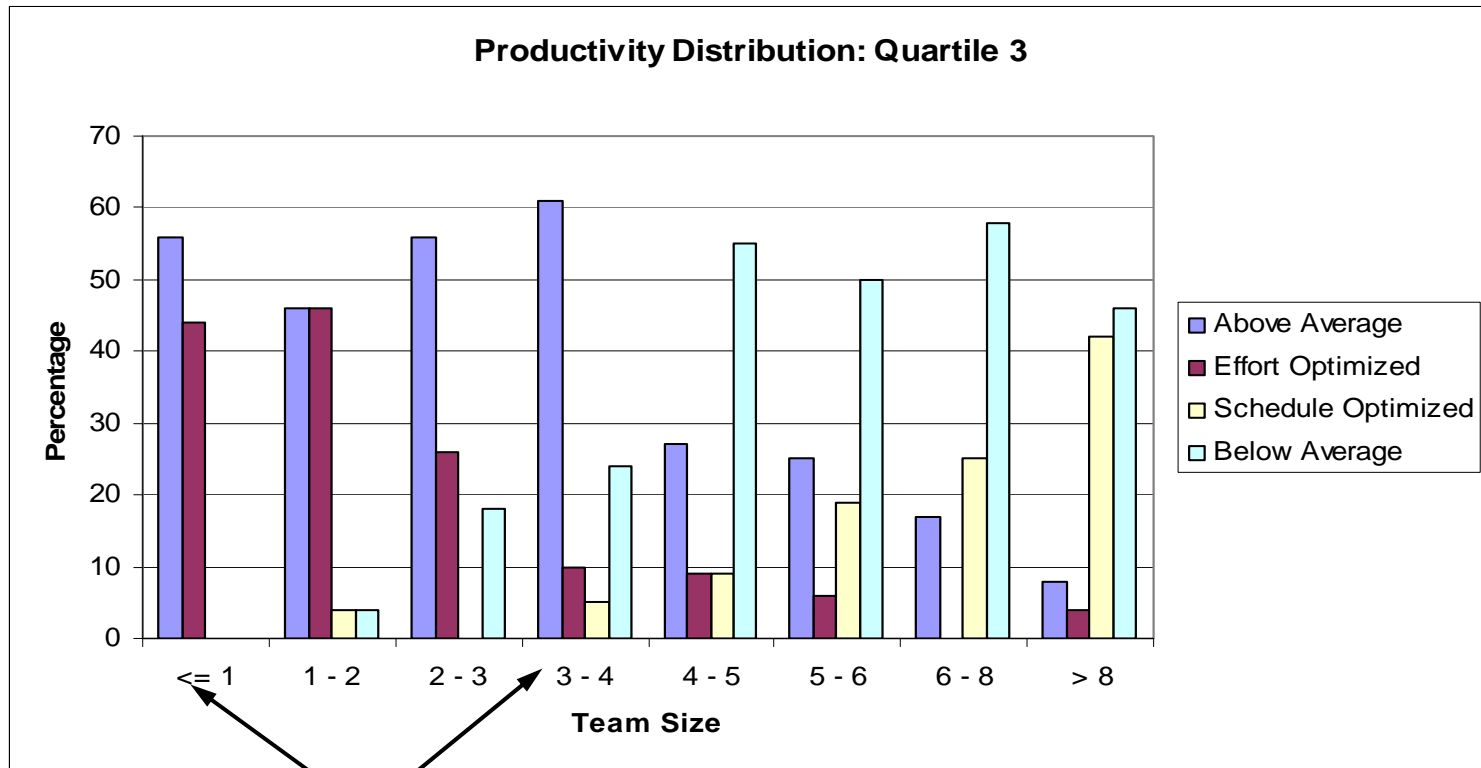
- **Wide latitude in staffing for better than average projects (for schedule)**
- **Effort optimization decreases with size: few projects with staff > 4 are effort optimized**
- **Staff 1 – 3 has best balanced probability of success**
- **Effort optimized and balanced probabilities very similar to patterns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

Quartile 2 Recommendations

- **Team size ≤ 3 best for producing better than average project for effort/cost**
- **Team size 1 – 3 provides best balanced probability for better than average project for effort & schedule**
- **Large teams (> 8) can be used effectively to optimize schedule**

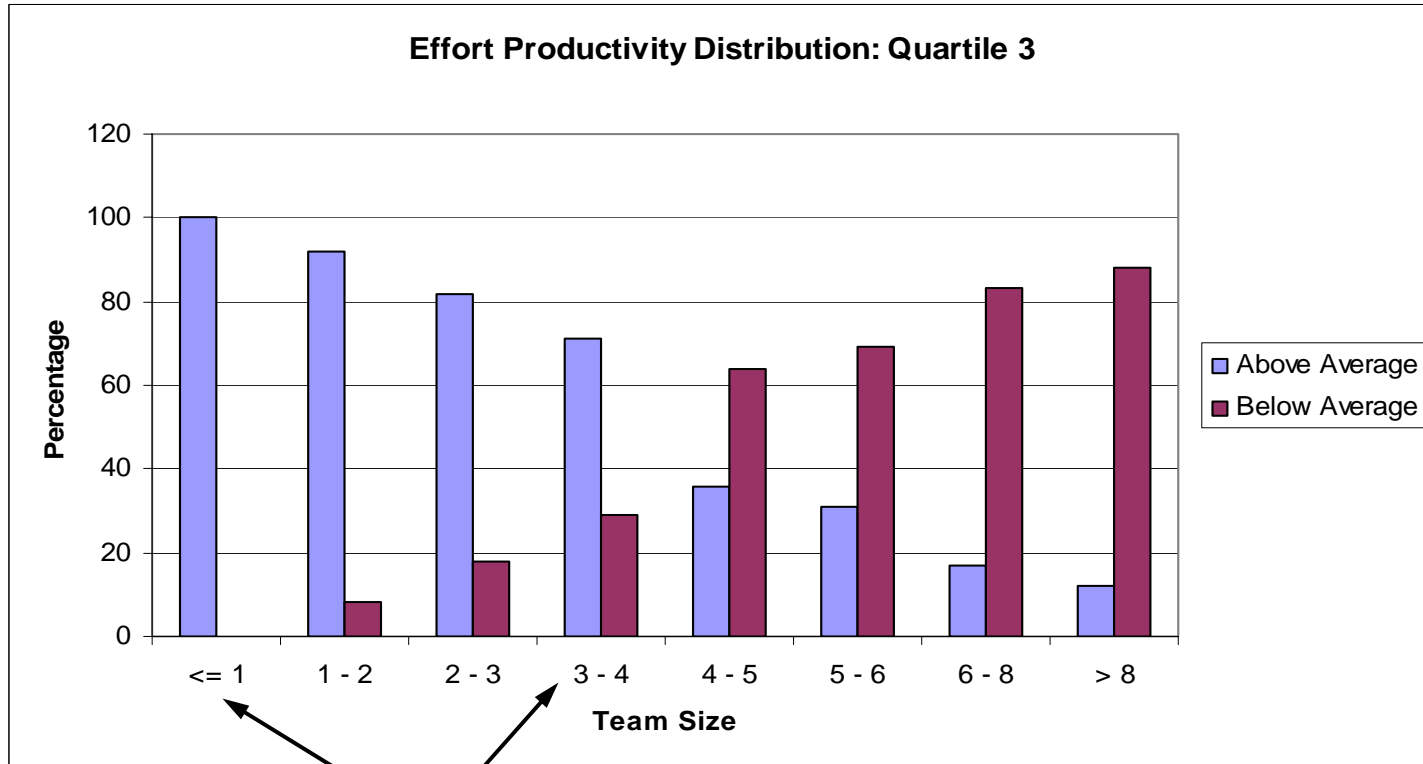
Quartile 3

8705 – 20647 ESLOC



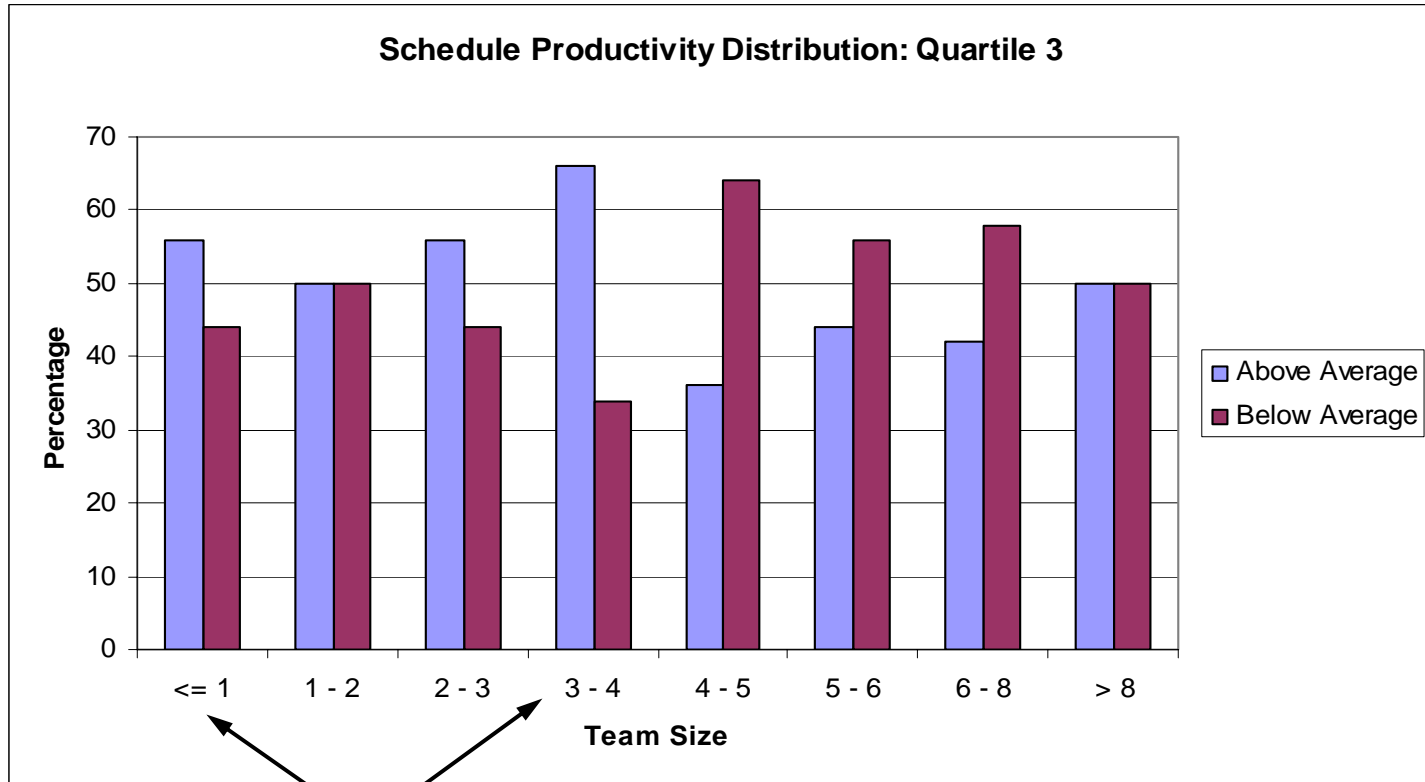
Team size of 4 or less provides best chance of balancing both schedule and cost/effort. Sharp drop-off with larger teams

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

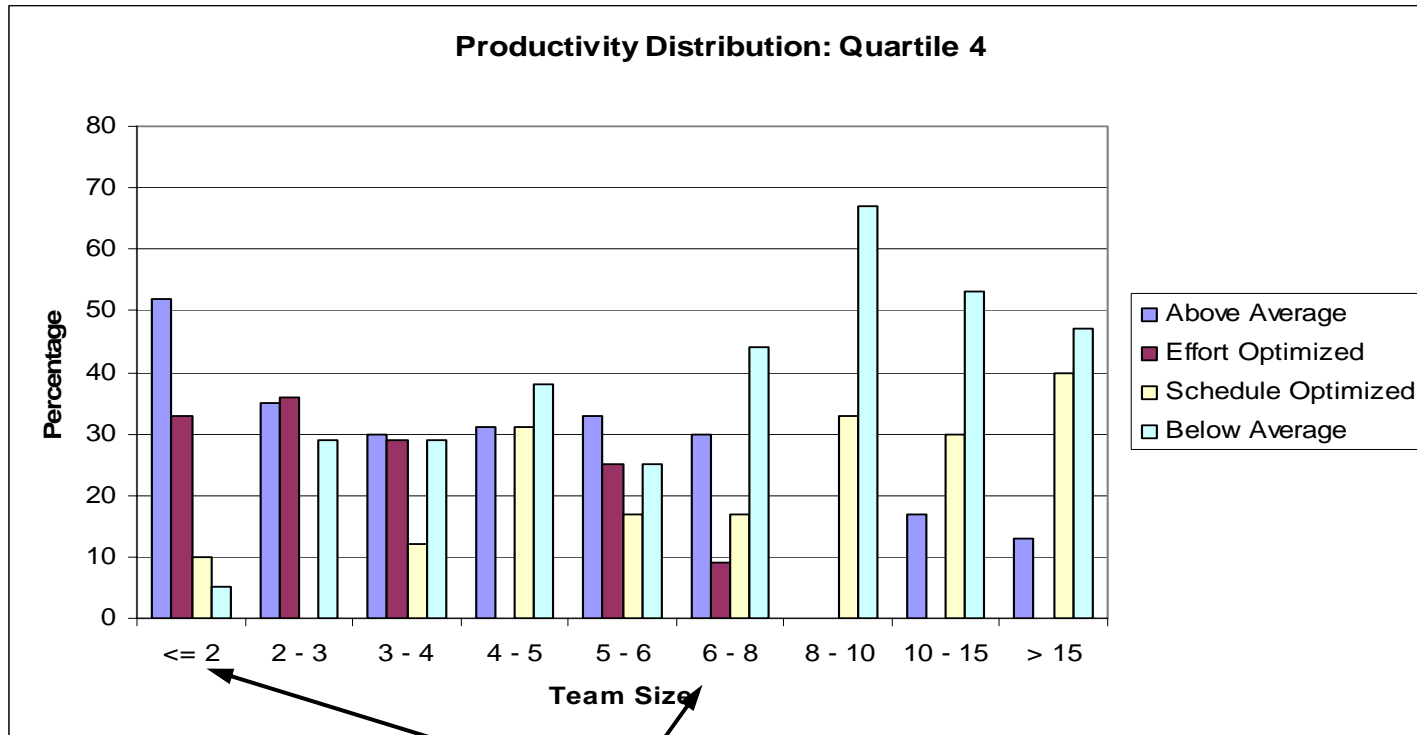
Quartile 3 Observations

- **% 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

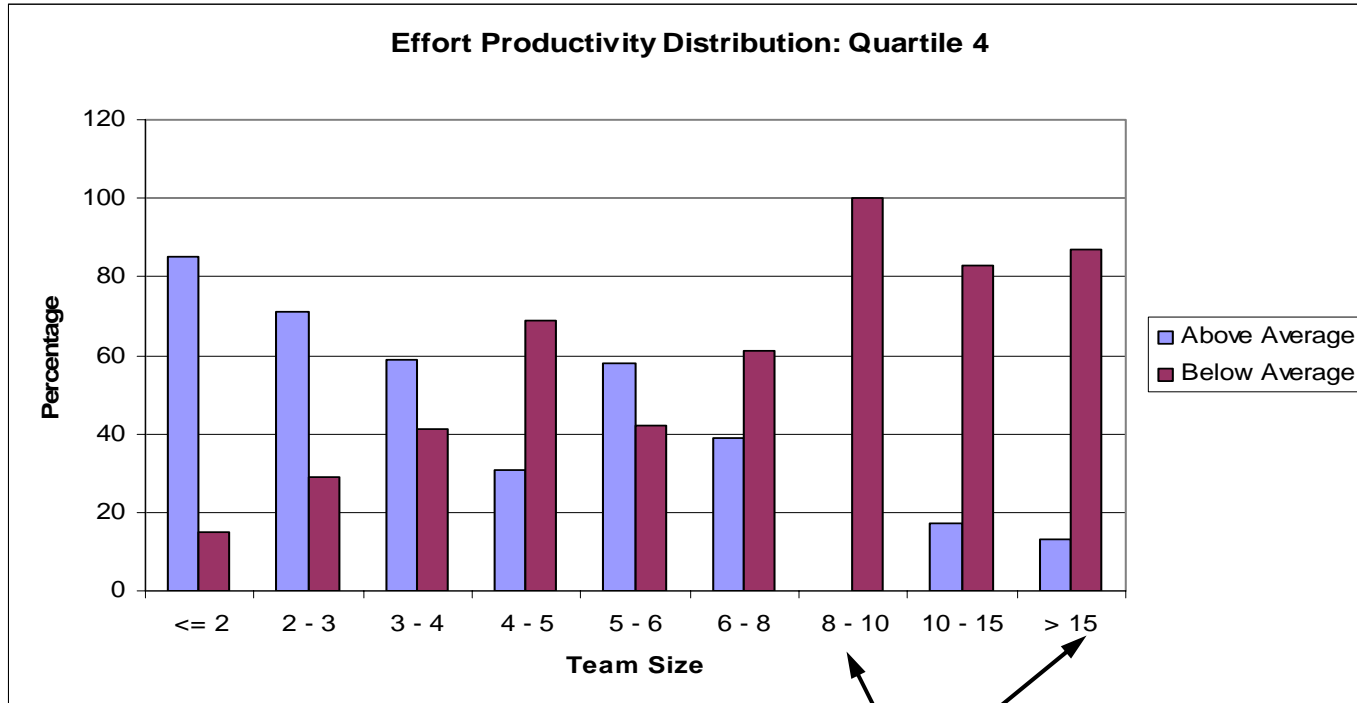
- **Team size 3 – 4 a good fit for these projects**
- **Smaller teams (< 3) a good fit if schedule pressure permits**
- **Avoid teams > 4**

Quartile 4 > 20647 ESLOC



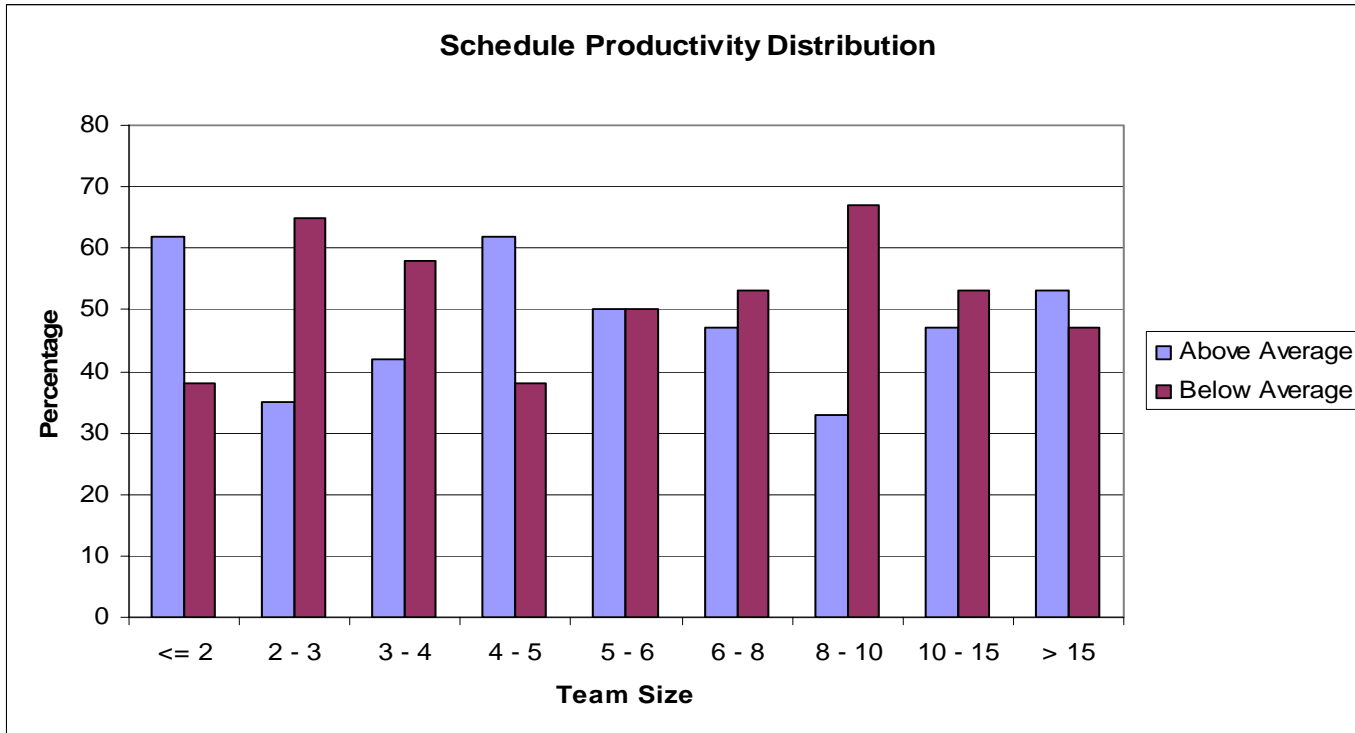
Balanced probability of success fairly consistent up to a team size of 8

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

Quartile	Schedule Optimized	Cost/Effort Optimized	Balanced Performance
1 - 4004 ESLOC	2 - 4	< 2	1 - 3
4005 - 8702 ESLOC	2 - 6	1 - 3	1 - 3
8703 - 20647 ESLOC	2 - 4	1 - 4	2 - 4
20647+ ESLOC	4 - 6	1 - 5	2 - 6
Large Projects > 70000 ESLOC	10 - 20	10 - 20	10 - 20

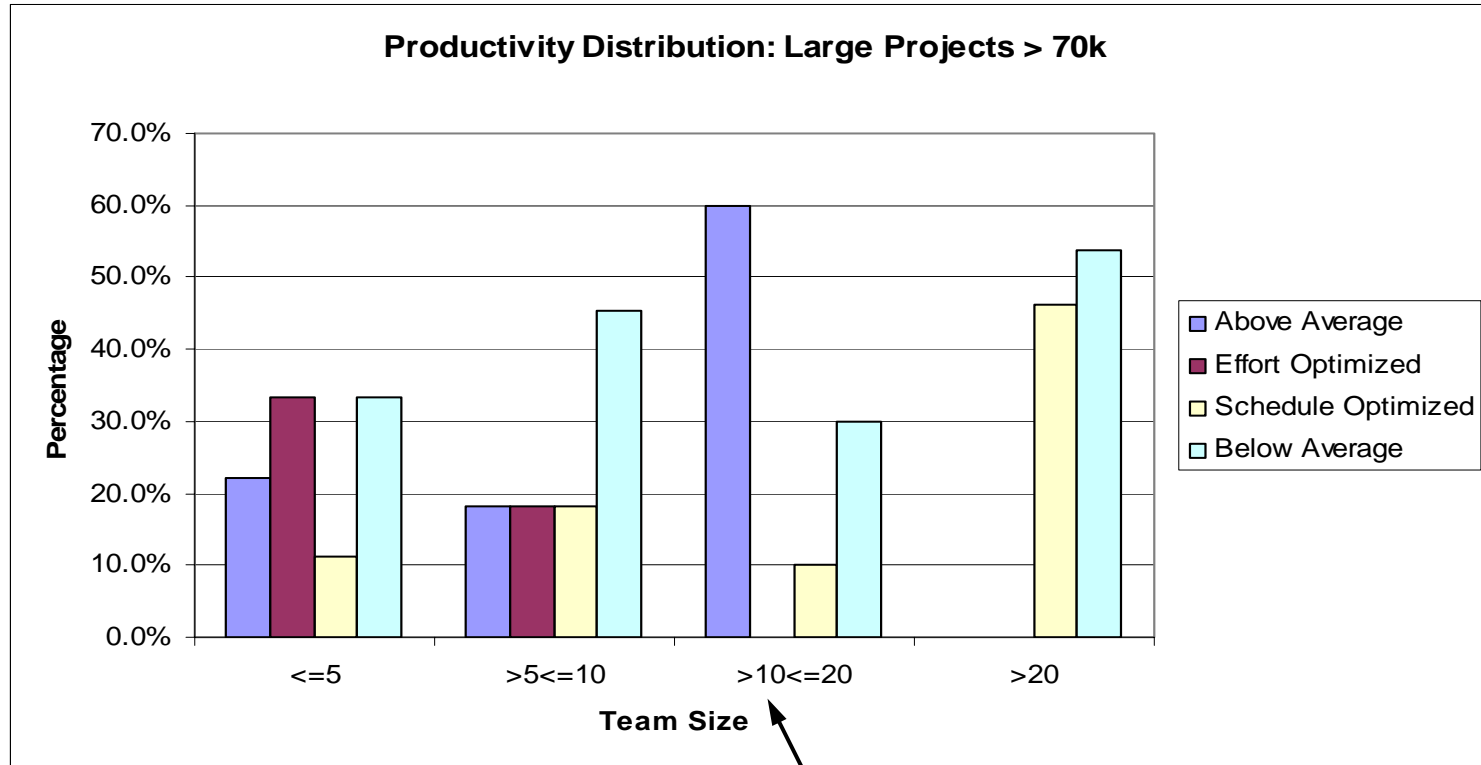
Overall Observations

- **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

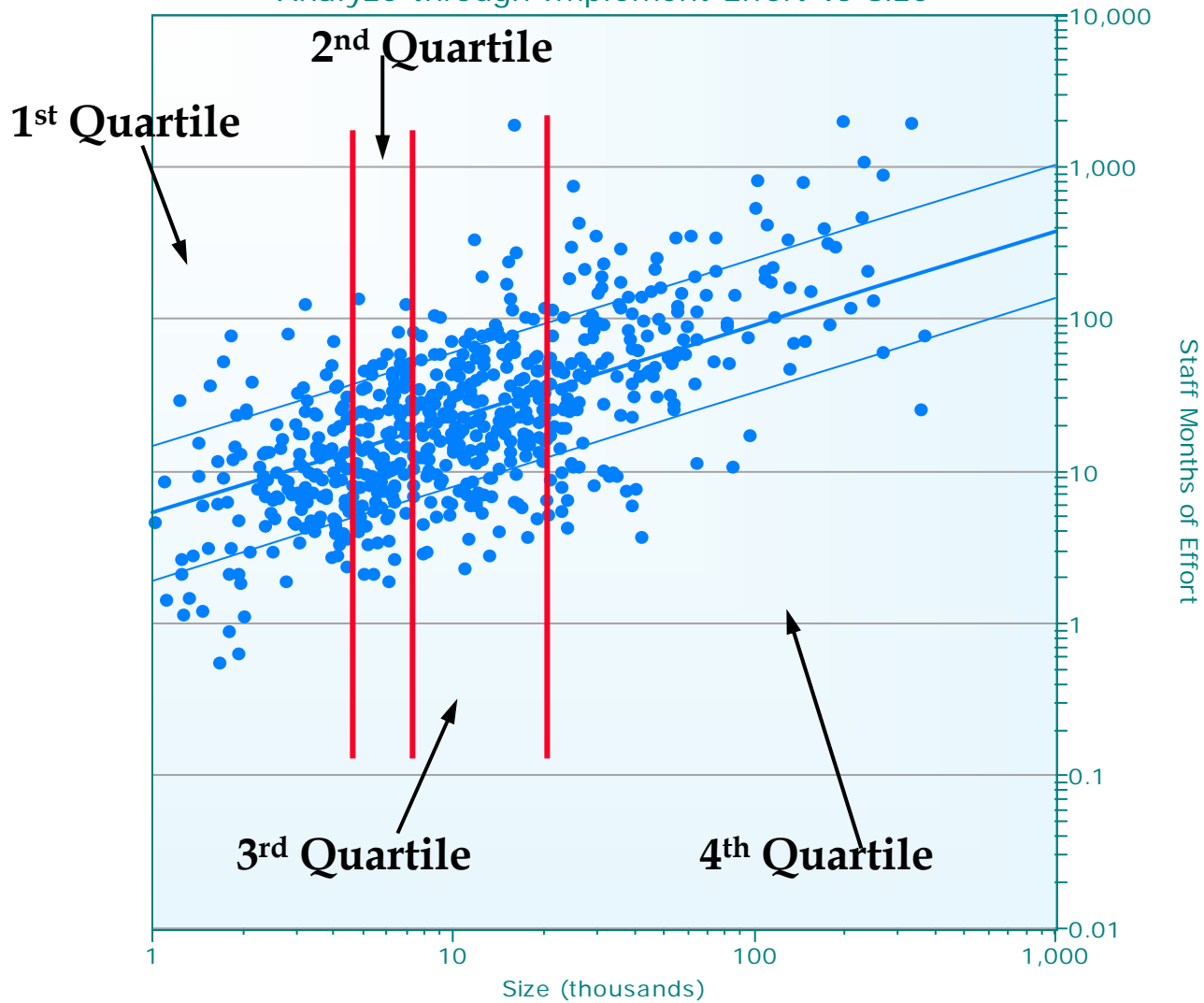
Very Large Project Observations

- **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



● — Business Systems — Avg. Line Style — 1 Sigma Line Style