teaching critical chain project mgmt

academic debate, open research questions, numerical examples and counter-arguments

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Goldratt’s *Critical Chain*, 1997

- Reviewed in academic and business press
- Initiated area of CCPM
- Dozens of scholarly and practitioner-oriented articles and books
- New consulting practices
- New PM scheduling software (e.g., ProChain)

CCPM success stories?

Survey 1: Herroelen, Leus, Demeulemeester 2002

Survey 2: Woeppel 2005

Survey 3: Leach 2005

2006 Edelman Award (Srinivasan, Best, Chandrasekaran 2007)
mixed academic opinion

• “critical chain” attributed to Wiest’s (1964) “critical sequence”
• “project buffer” attributed to O’Brien (1965)
• CCPM not empirically justified; contradicts well-known scheduling theory
  – Raz, Barnes, Dvir (2003), “a critical look at CCPM”
  – Trietsch (2005), “Why a critical path by any other name would smell less sweet? Towards a holistic approach to PERT/CPM”
CCPM vs. PERT/CPM?

- CCPM does not complement current PM practices; poses unnecessary methodological choice w/ PERT/CPM (Raz et al. 2003).

- “There is a variety of such methods some of which are mutually incompatible and attempting to describe them all is likely to cause confusion.” (Nokes et al. 2003)

- “Why do you teach PERT when we learn so much from Critical Chain?” (MBA student)
true or false? CCPM delivers successful projects

• “Everybody knows projects don’t finish on time or on budget, and even if they do, it means they had to compromise on content.” (Goldratt, p. 25)

• Case of Sydney Opera House (Shenhar & Dvir 2007)

• Case of LA Subway (Shenhar & Dvir 2007)

• Other elements known to be key to project “success” (Lipovetsky et al. 1997).

Conclusion: false (CCPM is purported only to give scheduling success)
true or false? “time, budget, content: choose 2”

• “Everybody knows projects don’t finish on time or on budget, and even if they do, it means they had to compromise on content.” (Goldratt, p. 25)
• Standish Group’s long-term study in IT: <30% of projects in 2004 were “on time and budget as designed” (Klastorin & Mitchell 2005)
• Other failure examples in Woeppel (2005), Leach (2005)

Conclusion: true*

*Scientific study of projects controlled with CCPM?

Millhiser & Szmerékovsky
true or false? focus on time, not cost

- “Companies are so immersed in the mentality of saving money that they forget that the whole intention of a project is … to make money. … It’s a simple fact that they try to cut the budget by a few % and cause the payback period to double.” (Goldratt, p. 62)
  - Accept 6-month delay, stay within product development budget? Lose 33% of profit.
  - Spend 50% over development budget, meet a release date? Lose 4% of profit.
- Deming’s point #4, “End practice of awarding business on price tag alone.” (Walton 1986)

Conclusion: true*

* “NPV Project Management” can identify what “on time” should mean (Herroelen et al. 1997).
true or false? recognize parallel activities

• “In the case of parallel steps, ... biggest delay is passed on the next step.” (Goldratt, p. 122)

• Projects with variable activity times always exceed time of deterministic critical path (greater variability or more parallel paths → greater delay; Schonberger 1981)

• More parallel paths → greater chance noncritical tasks turn critical → feeding buffers misplaced (Raz et al. 2003)

Conclusion: true
true of false? pool safety time in buffers (not tasks)

• “each step has a minimum 200% safety” which is exhausted needlessly due to “student syndrome” → cut time estimates ½; pool ½ of savings in project buffer (Goldratt, pp. 155-156).
• Weather-related padding in construction projects (Clough & Sears 1991).
• Deadlines are a form of quota → deadline elimination through pooling agrees with Deming’s point #11, eliminate numerical quotas (Trietsch 2005).
• Survey data & model → pooled safety buffers are appropriate in construction equipment procurement supply chain (Yeo & Ning 2006).
• Herroelen & Leus (2001):
  – “The … 50% task duration estimate may be based on loose ground. … the result might be an unnecessarily large amount of protection, which could lead to uncompetitive proposals and loss of business opportunities.”
  – Root-square-error method of buffer size estimation is more accurate.
• Raz et al. (2003):
  – Benefits of pooled buffers not empirically justified.
  – “Imposing shortened duration estimates on task owners will reduce their commitment to the estimates.”
  – “The knowledge that their estimates will be reduced is likely to encourage task owners to add larger margins so they still have the safety margin they prefer after the correction.”
  – Each added buffer is a new item on a Gantt chart → more clutter, potential confusion, unscheduled communication.

Conclusion: ???
true or false? **Feeding Buffers eliminate the ES vs. LS dilemma**

- If noncritical activities follow ES or LS times, project leader will lose focus, resulting in costly delays. Use feeding buffers (FB) to stagger start times (Goldratt, pp. 70-71).
- FB concept first appeared in the literature in the 1980s and 90s; “basic idea understood by the professional community long before publication of CC.” (Triesch 2005)
- “Pushing activities backward in time in order to insert a FB may … create resource conflicts. How these conflicts are to be resolved is not described in detail. A possible way … may be to push the chain of activities feeding a FB backwards in time until a feasible schedule is obtained again.” (Herroelen & Leus 2001)

Conclusion: **maybe**
true or false? CCPM avoids Parkinson’s Law

- “Work expands so as to fill the time available for its completion” (Parkinson 1955).
- “Almost ½ the steps were reported finishing … on the nose. … for almost 1/3 of the steps … the elapsed time was 10-20% longer than the original estimate” (Goldratt, pp. 123-124).
- 500 software development activities: 32% overran time estimates, 60% ahead of schedule; 8% “on target” (Hill et al. 2000).
- Parkinson’s Law is not necessarily bad, “since you cannot have the workforce under stress all the time.” (Herroelen & Leus 2001).
- “The advantages of procrastination are well documented: the closer to a deadline a task is executed, the less processing time the task appears to require. Hence, it is common for a person to delay executing some onerous job in order to spend as little time as possible working on it.” (Bender et al. 2008)

Conclusion: open question?
true or false? we should not multitask

- **Goldratt**: “mutli-tasking” = assignment if one entity to multiple tasks.
- **N. American culture**: multitasking = performing of multiple activities simultaneously; time savings.
- Assigning R&D employees to up to 3 simultaneous projects improved ROI. *(McCollum & Sherman 1991)*.

Conclusion: **false** - may make project manager’s life more difficult; may help department manager.
missing from the book...

• scope creep

• how to implement CCPM?
  – **print:** Woeppel 2005, Nokes et al. 2003, Srinivasan et al. 2007
  – **consulting:** Goldratt Institute, ProChain Solutions (many others)
  – **software:** ProChain Solutions
  – **warning:** “it would be very difficult for an isolated project manager to run a project using the critical chain unless it is widely understood within the organization and the necessary management support is given.” (Nokes et al. 2003)
activity 1: simple CCPM formulation

<table>
<thead>
<tr>
<th>Activity</th>
<th>Immediate Predecessor</th>
<th>Estimated Time (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>--</td>
<td>6</td>
</tr>
<tr>
<td>B</td>
<td>A</td>
<td>12</td>
</tr>
<tr>
<td>C</td>
<td>A</td>
<td>4</td>
</tr>
<tr>
<td>D</td>
<td>B, C</td>
<td>10</td>
</tr>
</tbody>
</table>

Two workers are available. Due to her skill set, Jill is responsible for activities A & D. Similarly, only Jack can do activities B & C.

(a) Expected project duration?
(b) Jack & Jill can be cross trained, but will not share activities. Would reassignment shorten project?
(c) Jill does A & B, Jack does C & D. Assume times in table are estimates padded with safety. Use ideas from CC to reformulate the project schedule using project and feeding buffers. Include a diagram similar to that on Goldratt’s p. 218.
activity 2: PERT vs. CCPM?

The Project of Reliable Construction Co. The Reliable Construction Company has just made a winning bid of $5.4 million to construct a new plant for a major manufacturer. The manufacturer needs the plant to go into operation within a year. Therefore, the contract includes the following provisions:

1. A penalty of $300,000 if Reliable has not completed construction by the deadline 47 weeks from now.
2. A bonus of $150,000 if Reliable delivers the plant within 40 weeks.

The following table shows the list of activities, immediate predecessors, and time estimates.

(a) Use the “50% rule” to reformulate each time estimate.
(b) Find feeding buffer and project buffer durations.
(c) Sketch CC diagram.

Source: Hillier & Lieberman (2001)
activity 2, cont’d

CCPM:  
- project duration = 36 weeks
- critical chain = A-B-C-E-F-J-L-N

PERT:  
- mean project duration = 44 weeks
- critical path = A-B-C-E-F-J-L-N
- Pr(project duration > 36) = 99.6%

- All three noncritical chains preceded by critical activities.
- Goldratt’s “50% rule” infeasible for all three FB’s (e.g., FB for D-G-H-M should be 6 weeks; only 5 available).
activity 3: practice with page 214, 218

Person “X” is the only employee with skills to accomplish B, D, F, K, M (other tasks have unique person assigned).

Develop a CC project schedule. Include a figure similar to that on p. 218; indicate the duration of activities and buffers.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Immediate Predecessors</th>
<th>Estimated Activity Time (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>--</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>A</td>
<td>4</td>
</tr>
<tr>
<td>C</td>
<td>--</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>C</td>
<td>9</td>
</tr>
<tr>
<td>E</td>
<td>--</td>
<td>2</td>
</tr>
<tr>
<td>F</td>
<td>E</td>
<td>5</td>
</tr>
<tr>
<td>G</td>
<td>F</td>
<td>3</td>
</tr>
<tr>
<td>H</td>
<td>G</td>
<td>8</td>
</tr>
<tr>
<td>I</td>
<td>B, D, H, K, M</td>
<td>4</td>
</tr>
<tr>
<td>J</td>
<td>--</td>
<td>3</td>
</tr>
<tr>
<td>K</td>
<td>J</td>
<td>2</td>
</tr>
<tr>
<td>L</td>
<td>--</td>
<td>1</td>
</tr>
<tr>
<td>M</td>
<td>L</td>
<td>7</td>
</tr>
</tbody>
</table>
activity 3: cont’d

Diagram if resource constraint ignored
(duraction = 16.5 weeks)
activity 3, cont’d

CC schedule if resource constraint observed
(duration = 24 weeks)
activity 4: resource constraints across multiple projects

Assume it is more expensive to delay project 1. Find the CC project schedule.

<table>
<thead>
<tr>
<th>Project 1</th>
<th>Activity</th>
<th>Immediate Predecessor</th>
<th>Estimated Time (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (Jill)</td>
<td>--</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>B (Jack)</td>
<td>A</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>C (Jack)</td>
<td>A</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>D (Jill)</td>
<td>B, C</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project 2</th>
<th>Activity</th>
<th>Immediate Predecessor</th>
<th>Estimated Time (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E (Jane)</td>
<td>--</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>F (Jack)</td>
<td>E</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>G (Jack)</td>
<td>E</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>H (Jane)</td>
<td>F, G</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>
activity 4, cont’d

Notes:

- Feeding buffer between E & F?
- What is the critical chain?
(Neither are clear in book.)
activity 5: multitasking counterexample

<table>
<thead>
<tr>
<th>Activity</th>
<th>Immediate Predecessor</th>
<th>Estimated Time (weeks)</th>
<th>Qualified Personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>--</td>
<td>0</td>
<td>--</td>
</tr>
<tr>
<td>B</td>
<td>A</td>
<td>3</td>
<td>Jack</td>
</tr>
<tr>
<td>C</td>
<td>B</td>
<td>1</td>
<td>Jill</td>
</tr>
<tr>
<td>D</td>
<td>C</td>
<td>3</td>
<td>Jack</td>
</tr>
<tr>
<td>E</td>
<td>A</td>
<td>6</td>
<td>Jill</td>
</tr>
<tr>
<td>F</td>
<td>D, E</td>
<td>0</td>
<td>--</td>
</tr>
</tbody>
</table>

- Jill may multitask C & E at the same time (no precedence constraints).
- Assume multitasking C & E requires 50% more time (requiring 3 weeks of multitasking to complete one week of work on C & E).
activity 5, cont’d

**without multitasking (10 weeks)**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>B (Jack)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C (Jill)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D (Jack)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E (Jill)</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**with multitasking (9 weeks)**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>B (Jack)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C (Jill)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D (Jack)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E (Jill)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
open questions

- Should we teach CCPM?
- If yes, should we teach CCPM and PERT/CPM?
- Is there a scientific study that compares the success rate of projects controlled with CCPM vs. PERT/CPM?
- Does CCPM really avoid Parkinson’s law?
- Software: Are any instructors using ProChain Solutions in the classroom? ($695 per copy)

Comments? Questions? Want a copy of paper? Did we miss anything?

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