Project Management

Lecture 9 Balancing TCQ

Dr. Andre Samuel

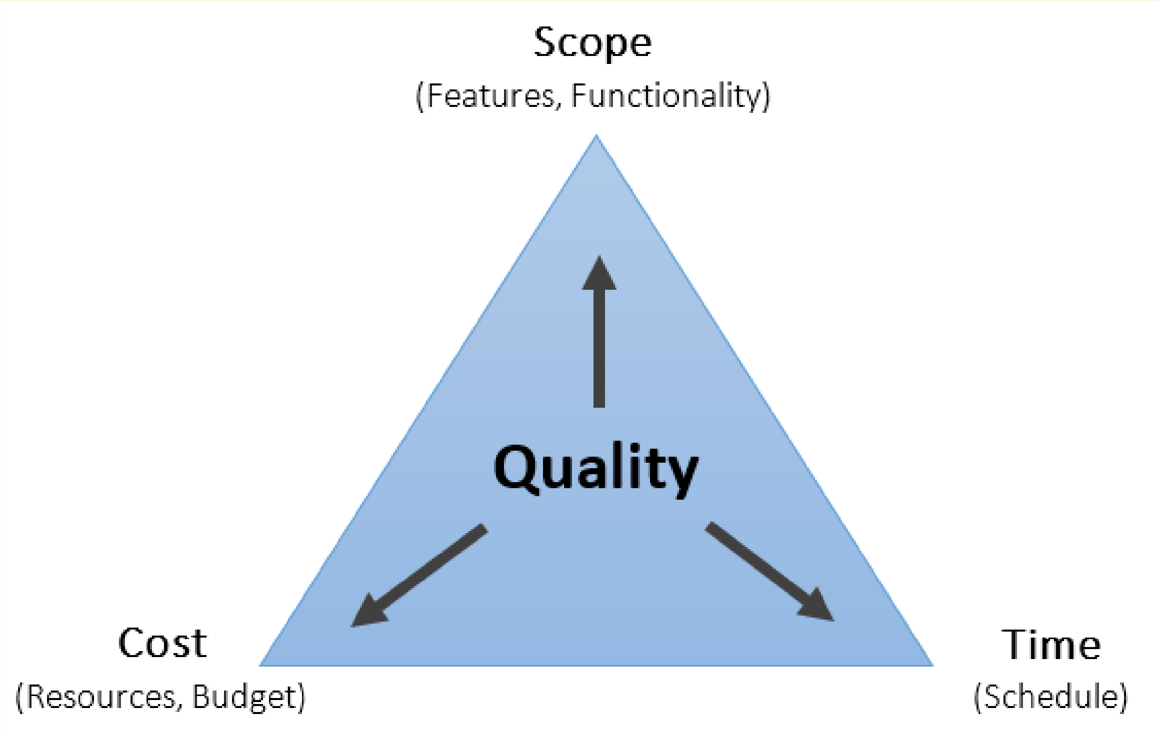
Previous Lecture

- Project Monitoring and Control

In this Lecture

- The Triple constraints
- Project Crashing
- Trade Offs

The Triple Constraints- Iron Triangle



Introduction

- Projects are generally undertaken because they are part of the plans to meet business needs and charter organizations to new levels of performance.
- Projects are however **constrained by conflicting demands and competing priorities** within the project environment.
- Neglecting to manage these constraints accurately and effectively may be sufficient to condemn a project even if all other project management activities are performed to a high standard of excellence.

The Priorities!

- A **time constrained** project is bounded by the completion agenda
  - Can result in Cost overruns
  - and unacceptable Quality

- A **cost constrained** project is bounded by expenditure.
  - Can result in the project not being completed on Time
  - And unacceptable Quality

- A **Scope constrained** projects are bounded by the performance criteria of the deliverables.
  - Can result in the project not being completed on Time
  - And Cost overruns

The Triple Constraints

- The triple constraint constitutes one of the primary building blocks of the project plan and is **paramount to the monitoring and controlling** process group
- The triangle reflects the fact that the **three constraints are interrelated and involve trade-offs**
  - one side of the triangle cannot be changed without impacting the others
- **Lack of understanding the dynamics** of the constraints results in project managers **not being able to effectively prioritize and exploit the triple constraint trade-offs**.

- Successful projects should be:
  - completed before project due dates and
  - within budget;
- There may therefore be significant variance between the assumptions made regarding a project and actual outcomes.
- Sudden unexpected changes in construction technology, techniques, materials, or human resources can create budgetary and scheduling pressures that in turn may increase the possibility of failure (Zeng et al., 2007).

The Role of Quality

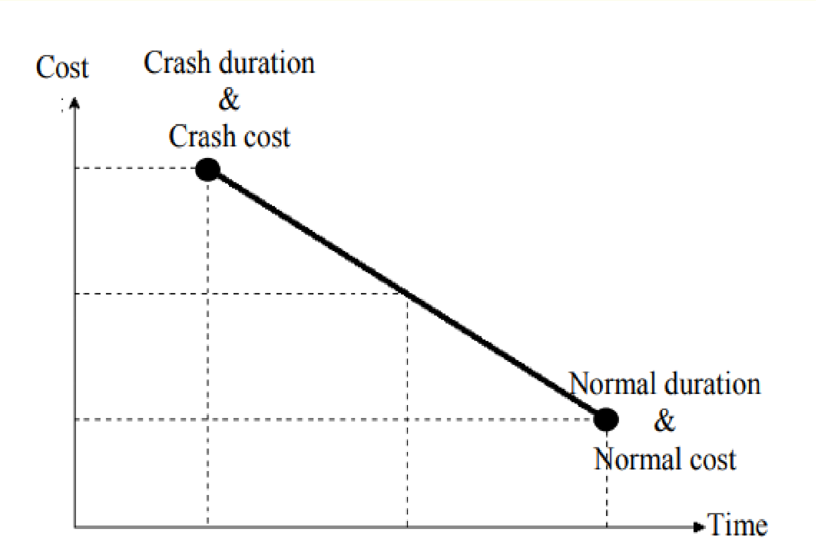
- Project **quality constitutes an integral dimension** of project management and is supported by the triple constraint
- Project **quality is affected by balancing these three factors**.
    - High-quality projects deliver the required product, service, or result within scope, on time, and within budget.

Theoretical Background

- **Time Cost Trade-off Problems (TCTP)** that have been extensively studied in the literature relates to deterministic project scheduling. Weglarz, Jozefowska, Mika, & Waligora, (2011)
- Time–cost trade-off problems mostly **concentrated on shortening overall project duration by crashing the time** required to complete individual activities.
- Under the assumption that time and cost trade-offs for individual activities are linear, the relationship can be represented as a straight line on a graph depicting the relationship between activity time and cost (Wiest and Levy, 1997).
- The cost of completing the activity varies linearly between the normal time and the crash time (Fulkerson, 1961).

Crashing- Time and Cost Curve

- In order **to reduce the time** estimate and save time on the project, there will almost certainly be a requirement to **increase resources.**
- This will allow the project to finish more quickly but will result in a cost increase.
- It is possible that some intermediate point may represent **the ideal or optimal trade-off between time and cost**
- The slope of the line connecting the normal point (lower point) and the crash point (upper point) is called the **cost slope**



Cost slope = crash cost – normal cost / normal duration – crash duration

Example

Activity	Normal Duration (wk)	Crash Duration (wk)	Normal Cost ($)	Crash Cost ($)	Crash Increase	Crash Cost per week
A	8	6	20000	40000	20000	10000
B	6	4	25000	49000	24000	12000
C	8	7	18000	36000	18000	18000
D	7	6	30000	45000	15000	15000
E	4	3	38000	54000	16000	16000

Calculate the crash sequence. The crash sequence will usually start with the cheapest unit-crash-cost item and progress to the most expensive unit-crash cost item.

From the example, the obvious order for crashing is therefore A, B, D, E, and C.

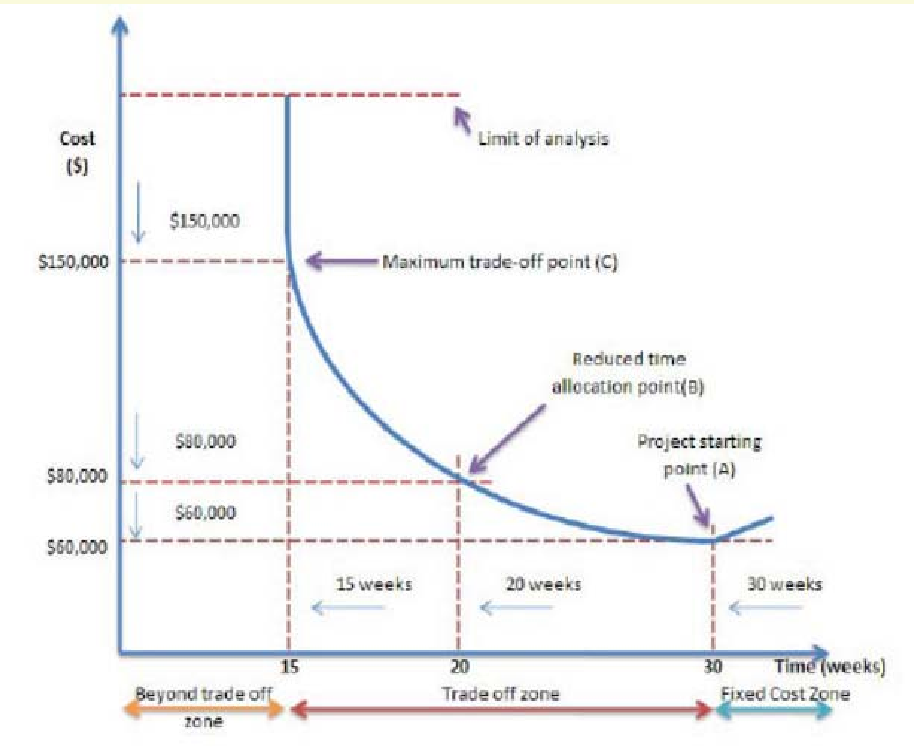
Calculate Project Cost Increase

Activity	Crash Cost per week ($)	Normal Duration (wk)	Crash Duration (wk)	Time Saved (weeks)	Cumulative project cost increase ($)	Cumulative project duration reduction (weeks)
A	10000	8	6	2	+20,000	-2
B	12000	6	4	2	+44,000	-4
D	15000	7	6	1	+59,000	-5
E	16000	4	3	1	+75,000	-6
C	18000	8	7	1	+93,000	-7

Optimization

- The most obvious way is to work out which activity can be speeded up at least cost, and then crash (i.e., reduce the overall activity duration) that one first, followed by the next cheapest, and so on.
- This will result in the typical **negative time-cost curve**, increasing in gradient as overall time for the project decreases.
- This curve will reach a point where all critical-path activities have been speeded up as far as possible.
- **Beyond this point, no further time can be saved on the project. Any further crashing will result in cost increases, and no further time will be saved.**

Optimization



- Point (A) represents the original starting point, where the project will take 30 weeks to complete.
- This is the agreed tender amount and the agreed project duration. In this case, the tender amount is $60 000 and the project duration is 30 weeks.
- Point (B) is where the time allocated is reduced to 20 weeks, and the cost increases to $80 000.
- Point (C) represents the shortest time possible, in this case 15 weeks, and cost increases to $150 000. Beyond point (C), no further time-savings are possible.

- If there is concern over quality degradation then crashing project activities is not desirable, and more time should be allowed to finish the project (Deckro et al., 1995; Vrat and Kriengkrairut, 1986).
- Once a project has been completed, the time and cost trade-off problem is no longer an issue for the project manager, and quality or performance becomes key issues (Avots, 1984).
- Simply completing the project by the given due date and within budget is not sufficient, because the work must also be of acceptable quality Kim et al (2012)
- If the outcome of a project meets or exceeds the project contractor's expectations, the project is deemed successful (Martin and Tate, 2001).

Assumptions and Nature of Relationship

- The Triple Constraint says that **cost is a function of scope and time**
  - **if we want to shorten the time we must increase cost.**
  - **if we want to increase scope we must increase cost or schedule.**
- The relationship depends on which factors are fixed and which are flexible.
- That is the Priorities!
- It should be highlighted that the changes are not always symmetric, i.e. **if two variables need to increase, one may increase proportionally more than the other**

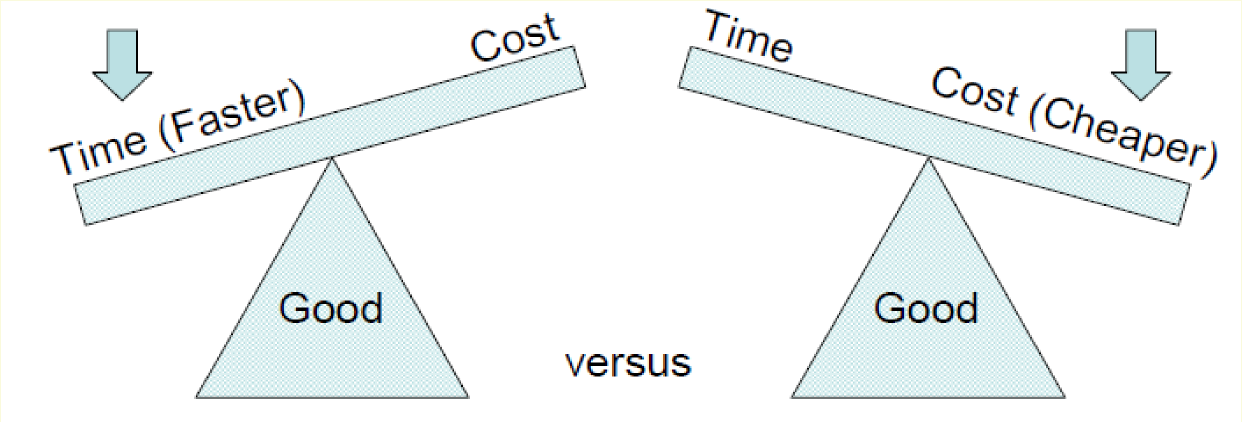
Trade- Offs

Good, fast, or cheap? Pick two

- The notion is that projects are generally constrained to choose two of the three elements and sacrifice the other in order to gain the chosen two
- One can choose either:
  - **(Q) good-**and**- (T) fast**, or
  - **(Q) good-**and**- (C) cheap**, or
  - **(T) fast-**and**- (C) cheap**;

  but critically not all three

- **If pressure is put on timescales** (fast) then **costs can be expected to go up;**
- alternatively, **if pressure is put on costs** (cheap) then **timescales can be expected to go up**



Good-and-fast vs. good-and cheap
Barker & Cole (2007) Seesaw Model

The 3 Key Relationships

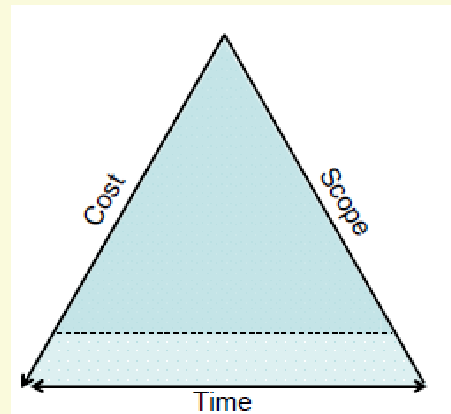
- From the seesaw model example it is clear that, with the scope/quality of work (good) remaining pivotal,
- The project cannot be delivered simultaneously fast and cheap as well
- One of the elements has to be flexible!!!

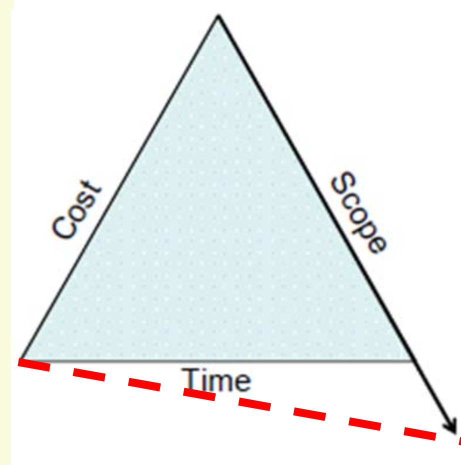
1. **Maximizing Quality:** *Q*↑ = *T*↑ *C*↑
2. **Reducing Time:** *T*↓ = Q↓ *C*↑
3. ***Reducing Cost:*** *C*↓ = Q↓ *T*↑

where the up-arrow (↑) implies an increase, the down arrow (↓) implies a decrease, and Q, T, and C refers to quality, time and cost respectively.

Maximizing Quality: Q↑ = T↑ C↑

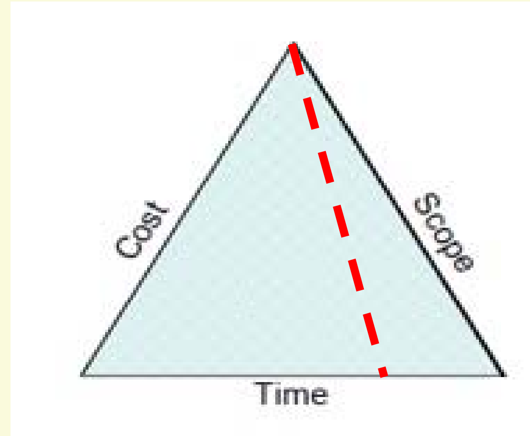
- The effect of increasing quality (Q↑), or effort (pressure) to achieve scope:
  - necessitates an increase in time (T↑) and cost (C↑).
  - If cost remains unchanged, then the project can be delivered good (because Q↑) and cheap (because C fixed as planned) but not fast (because T↑);

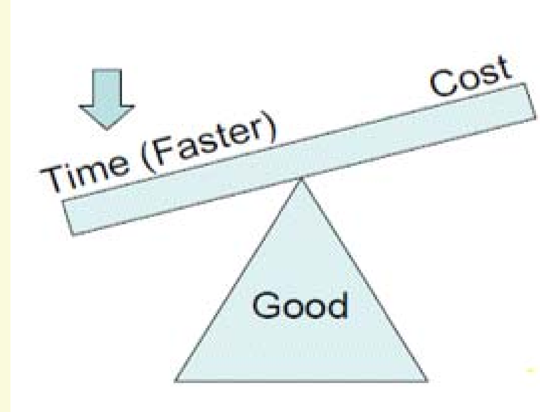




Reducing Time: T↓ = Q↓ C↑

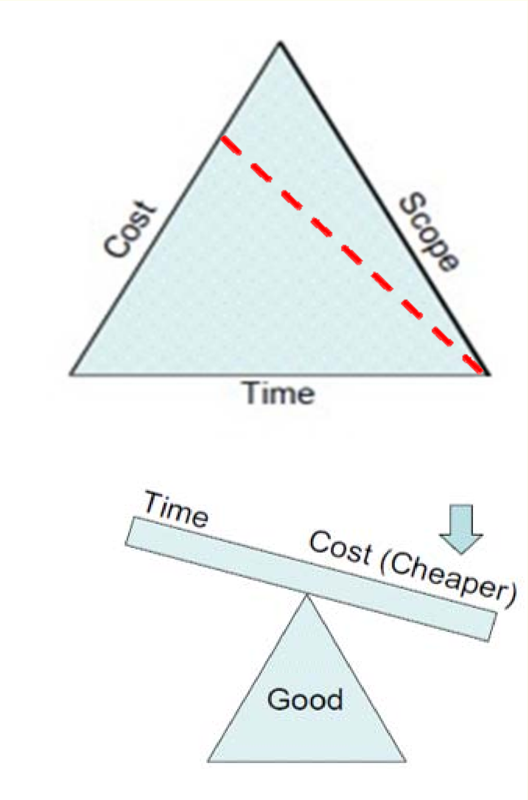
- The effect of reducing time (T↓), or effort (pressure) to achieve time:
  - necessitates a reduction of scope/quality (Q↓) and/or an increase in cost (C↑).
  - If Quality needs remains unchanged, then the project can be delivered fast (because T↓) and good (because Q fixed as planned) but not cheap (because C↑);



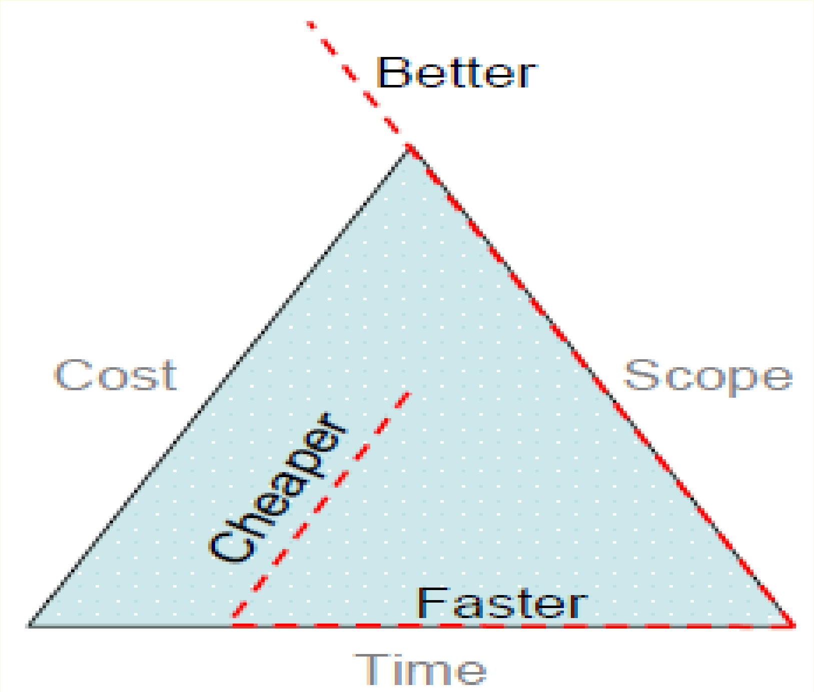


Reducing Cost: *C*↓ = Q↓ *T*↑

- The effect of reducing cost (C↓), or effort (pressure) to achieve cost:
  - necessitates a reduction of scope/quality (Q↓) and/or an increase in time (T↑).
  - If Quality remains unchanged, then the project can be delivered cheap (because C↓) and good (because Q fixed as planned) but not on Time (because T ↑).



Better, faster, cheaper – is this really possible?



Piarco International Airport

– **Estimated Cost- $741m**
– **Scope**: new terminal building, high-speed taxiways, extended car park facilities for staff and public, and a connecting road between the old and new terminal facilities.
– **Started** in 1998
– 11 month project
– **Commissioned** in July 2001
– **Completion Cost:** $920m

- NAPA
  - **Completion: Nov 2009**
  - **Scope: 1500 seat hall, 2 practice halls, hotel,** teaching rooms
  - **Estimated Cost: TT$ 500 Million**
  - **Funding: 2% concessional loan from Republic of China** for 20years
  - **Project Issue: Structural Defects TT$ 80 Million**
  - **Contractor: Fixed Price, Design Build contract to** Shanghai, but TT$ 100Million subcontracted to local contractors

Water Front Project

- **Commencement:** August 2005
- **Scope: Two 26 Storey Office buildings, A 22** storey 428 room Hyatt Regency, 7 storey carpark-1200 vehicles
- **Scheduled Open: 2008**
- **Actual Opening: April 2009**
- **Estimated Cost: TT$ 1.6 Billion**
- **Actual Cost: TT$ 3.4 Billion**
- **Funding: Loan, First Caribbean fixed interest rate** of 6.09 per cent for 15.9 years

Brian Lara Stadium

Conceptualization Date: 2003

- **Initial Estimated Cost: TT$ 850 Million, TT$ 275 M** for Cricket Stadium
- **Scope: – Cricket stadium, the aquatic centre, cycling** velodrome, football fields, gym, hotel accommodation
- **Estimated Completion Date: Cricket World Cup 2007**
- **Estimated Cost at Completion: TT $ 1.2 Billion**
- **Opening Ceremony: May 12 2017** after TT $ 90 Million repair cost
- **Used for CPL Final 2017 and 2018**

Reference List

- Barker, S. and Cole, R. , (2007) Brilliant project management: What the best project managers know, say and do. Harlow, UK: Pearson Prentice Hall Business,.
- Van Wyngaard, C. J. , Pretorius, J. H. C. and Pretorius, L. (2012) Theory of the Triple Constraint – a Conceptual Review, Proceedings of the 2012 IEEE IEEM
- Weglarz, J., Jozefowska, J., Mika, M., & Waligora, G. (2011) Project scheduling with finite or infinite number of activity processing modes: A survey. European Journal of Operational Research, 208, 177–205.
- Wiest, J.D., Levy, F.K., (1997) A Management Guide to PERT/CPM: Englewood Cliffs. Prentice-Hall, Inc, New Jersey
- Fulkerson, D., (1961) A network flow computation for project cost curves. Management Science 7 (2), 167–178.

- Deckro, R.F., Hebert, J.E., Verdini, W.A., (1995) Nonlinear time/cost tradeoff models in project management. Computers &Industrial Engineering 28 (2), 219–229.
- Vrat, P., Kriengkrairut, C., (1986) A goal programming model for project crashing with piecewise linear time–cost trade-offs. Engineering costs production. Economics 10, 161.
- Avots, I., (1984) Information systems for matrix organizations in Cleveland. In: David, I. (Ed.), Matrix Management Systems Handbook. Van Nostrand Reinhold, New York
- Martin, P.K., Tate, K., 2001. Getting Started in Project Management. John Wiley & Sons Inc, New York