2022

Navy Expeditionary Readiness Cost Modeling

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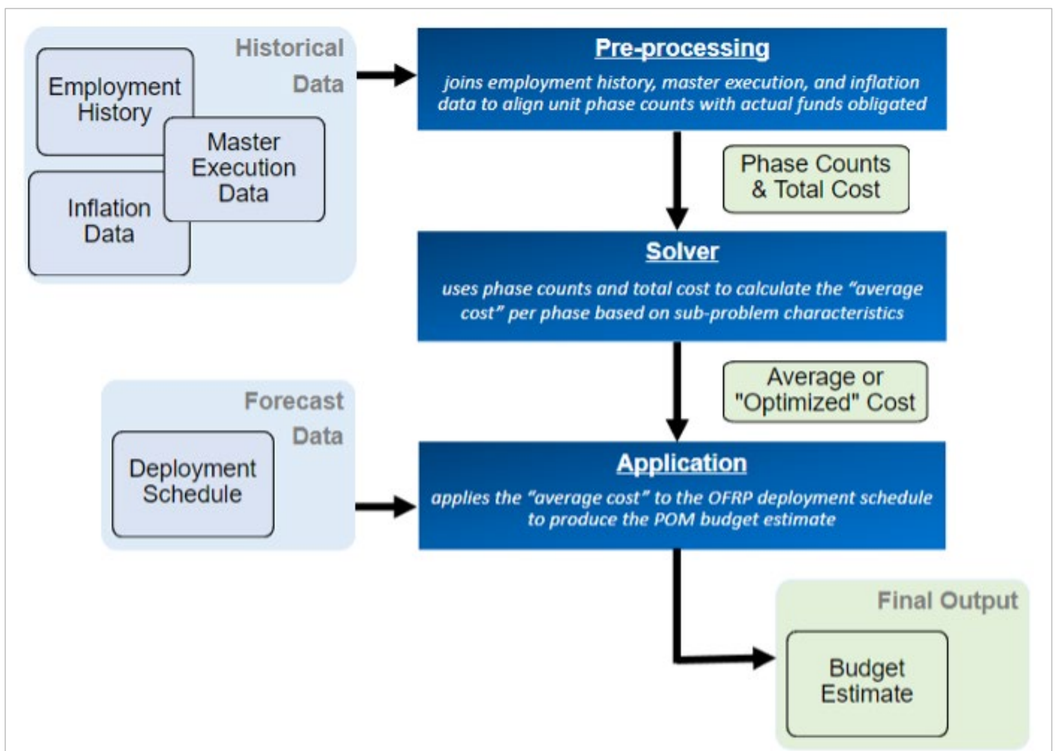
Introduction

- OPNAV N834 (Expeditionary Readiness) uses an N81 accredited Capability Costing Model (CCM)
- The existing CCM was developed many years ago by contractors who are no longer connected to its continued usage
- Documentation on the model is not available
- The CCM is implemented in Visual Basic for Applications (VBA)
- We dissected the VBA code to provide a formal mathematical description of the model and then reimplemented it in the Python programming language



Overview of the cost modeling process

Quadratic Programming Model

Indices and Sets

- $P = \{b, a, s, m, d\}$ – set of ORFP phases
- T – time periods

Parameters

- $r_{p,t}$ – allocation factor for phase $p \in P$ at time $t \in T$
- c_t – total cost during time period $t \in T$
- $\alpha \in [0,1]$ – percentage (based on Unit Program and APPN)
- $\beta \in \{1,2\}$ – weight (based on Unit Program and APPN)

Decision Variables

- x_p – average cost allocated to phase $p \in P$

$$\text{Minimize} \quad \sum_{t \in T} \left(c_t - \sum_{p \in P} r_{p,t}\, x_p \right)^2 \tag{1}$$

$$\text{subject to} \quad \sum_{t \in T} \sum_{p \in P} r_{p,t}\, x_p = \sum_{t \in T} c_t \tag{2}$$

$$x_s - \beta x_b \geq 0 \tag{3}$$

$$x_s - \beta x_a \geq 0 \tag{4}$$

$$x_b - x_m \geq 0 \tag{5}$$

$$\alpha x_m - (1-\alpha)(x_b + x_a + \beta x_s) \geq 0 \tag{6}$$

$$\alpha x_a - (1-\alpha)(x_b + x_m + \beta x_s) \geq 0 \tag{7}$$

$$x_p \geq 0, \qquad \forall p \in P \tag{8}$$

Computational Experiments

- We performed computational experiments on 678 problems in "POM23 Solver file for NCCM.xlsm"
- VBA using the GRG Nonlinear method in Solver ran all 678 subproblems in 3002 seconds
- Our Python implementation, using Gurobi optimizer, reduced the total run time to 63 seconds
  - an improvement in speed of 48x faster
- We compared the results obtained from Excel to those obtained from our Python model.
  - Absolute or relative difference >0.01 was set as the threshold to classify solutions as different
  - 647 problems produced equivalent solutions, whereas 31 problems yielded different results
  - differences are attributed to multiple solutions with the same objective value

Defense budget materials

Findings

- A lack of continuity between model developers and those currently maintaining it led to methodologically problematic implementation updates
- Unintentional effects included invalidating the intended constraint system and objective

Recommendations

- CCM was originally designed with constraints presumably based on outdated assumptions that are largely unknown
- Future studies should focus on validating if the cost model design is suitable and effective

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Topic Sponsor: N8 – Integration of Capabilities & Resources

NRP Project ID: NPS-22-N252-A

Technical Report: https://calhoun.nps.edu/handle/10945/70794

This research is supported by funding from the Naval Postgraduate School, Naval Research Program (PE 0605853N/2098). Approved for public release; distribution is unlimited.