Calibration Results of COCOMO II.1997

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Presentation Outline

→ COCOMO calibration
   Calibration process
   Results to date
   • Plans to Improve Accuracy
   • Information Sources
COCOMO II Calibration Process

• Began with expert-determined a-priori model parameters
  – Iterated with Affiliates (Result => A-Priori Post Architecture Model)

• Collected Data

• Identified and consolidated highly correlated model parameters

• Statistically determined estimates of consolidated model parameters from data
  – Using logarithms to linearize regression

• Used data determined model parameters to adjust a-priori model parameters
  – Experimented with weighting factors
### Consolidated Highly Correlated Parameters

<table>
<thead>
<tr>
<th></th>
<th>TIME</th>
<th>STOR</th>
<th>ACAP</th>
<th>PCAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIME</td>
<td>1.0000</td>
<td>0.6860</td>
<td>-0.2855</td>
<td>-0.2015</td>
</tr>
<tr>
<td>STOR</td>
<td>0.6860</td>
<td>1.0000</td>
<td>-0.0769</td>
<td>-0.0027</td>
</tr>
<tr>
<td>ACAP</td>
<td>-0.2855</td>
<td>-0.0769</td>
<td>1.0000</td>
<td>0.7339</td>
</tr>
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<td>PCAP</td>
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</tr>
</tbody>
</table>

- **What do we do?**
  - Combine: TIME & STOR to give RCON (Resource Constraints)
  - ACAP & PCAP to give PERS (Personnel Factors)

Thus, 15 effort multipliers instead of 17 for calibration.
## Statistical Data Analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Ratio (Max/Min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EFFORT</td>
<td>6</td>
<td>11400</td>
<td>1900</td>
</tr>
<tr>
<td>SIZE</td>
<td>2.6</td>
<td>1292.8</td>
<td>497</td>
</tr>
</tbody>
</table>

Thus, we took log transforms to normalize the response variable. Also, we took log transforms to linearize the parametrized model.
Expanded COCOMO

• Distributed the Scale Factors

• Resulted in 21 predictor variables i.e. 15 Effort Multipliers + 5 Scale Factors + (Size)$^{1.01}$

$$PM_{est} = A \cdot (Size)^{1.01} \cdot (Size)^{SF_1} \cdot (Size)^{SF_2} \cdot EM_1 \cdots EM_{15}$$

Log Transformed COCOMO:

$$\ln(PM_{est}) - \ln(Size)^{1.01} = \ln(A) + SF_1 \ln(Size) + \cdots + \ln(EM_{15})$$

• Regression analysis derived the coefficients, $B_i$, for each factor
RUSE Effort Multiplier

- Example of the effect of a negative coefficient
Distribution of RUSE

Frequency

RUSE

0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6

Distribution of RUSE

Frequency

RUSE

0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6
Overview

- 83 Observations from different Industrial categories including Commercial, Aerospace, FFRDC

- Log transformations of Original Post Architecture Model to achieve linearity for linear regression analysis

- 21 predictor variables i.e. 15 Effort Multipliers + 5 Scale Factors + Coefficient A

- Forecast accuracy measured with proportional error:

\[
PE = \begin{cases} 
\left[ PM_{est} \div PM_{act} \right] - 1, & (PM_{est} - PM_{act}) \geq 0 \\
- \left[ PM_{act} \div PM_{est} \right] + 1, & (PM_{est} - PM_{act}) < 0
\end{cases}
\]
# Accuracy Results

## Effort Prediction

<table>
<thead>
<tr>
<th>Prediction</th>
<th>Before Stratification By Organization</th>
<th>After Stratification By Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRED(.20)</td>
<td>46%</td>
<td>49%</td>
</tr>
<tr>
<td>PRED(.25)</td>
<td>49%</td>
<td>55%</td>
</tr>
<tr>
<td>PRED(.30)</td>
<td>52%</td>
<td>64%</td>
</tr>
</tbody>
</table>

## Schedule Prediction

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>PRED(.20)</td>
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<tr>
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<td>61%</td>
</tr>
<tr>
<td>PRED(.30)</td>
<td>61%</td>
<td>62%</td>
</tr>
</tbody>
</table>
Conclusions: Calibration Results

- Regression technique can be used to calibrate COCOMO locally using completed project data.
- New cost drivers can be added and calibrated without destroying the structure of the COCOMO model.
- COCOMO calibrated to local organization is more accurate than using generic COCOMO II model.
- More project data is required to facilitate better calibration of generic COCOMO II model.
- 1990’s software data presents more challenges:
  - Non-sequential processes: where are end-points?
  - Incremental development: how to separate the increments?
  - COTS, reuse, breakage, mixed language levels: what is size?
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Plans to Improve Accuracy

• Bayesian Regression Analysis
• Stratify data based on Language Level and Application Type
• Effort distribution based on activities
• Enhancement of COCOMO II database to continuously update the model
Successive versions of COCOMO II

- The 1997 version
  - Multivariate Linear Regression with 10% weighted average of expert-determined and data-determined

- The 1998 version
  - Bayesian Regression Analysis
    - Weighted average
    - Separate weights for each parameter based on significance
    - Model more Data-Determined

- The 19??/20?? version
  - 100% Data-Determined
Evolving Model Values

Number of projects used in calibration

100% Data Driven

100% Expert Driven

10

50

100

Bayesian Regression - COCOMO II.1998 version

Linear Regression - COCOMO II.1997 version

Our aim
Bayesian Approach

A-posteriori Bayesian update

Productivity Range = Highest Rating / Lowest Rating

A-priori
Experts’ Delphi

Noisy data analysis

Literature, behavioral analysis
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Information Sources

- Phone: (213) 740-6470
- Email: cocomo-info@sunset.usc.edu
- Web site: http://sunset.usc.edu/COCOMOII/Cocomo.html
  - Affiliate Prospectus
  - Model Definition Manual (ver. 1.4)
  - Data Collection Form (ver. 1.6)
  - Java COCOMO
  - Little Expert COCOMO Calculator