Impact of Base Functional Component Types on Software Functional Size based Effort Estimation

Luigi Buglione & Cigdem Gencel

Profes 2008
9th International Conference on Product Focused Software Process Improvement

BLEKINGE INSTITUTE OF TECHNOLOGY

Université du Québec
École de technologie supérieure

ENGINEERING

Agenda

- The Effort Estimation Problem
- Common Approaches to Effort Estimation
- Our Approach to Effort Estimation
- Empirical Study
- Discussion of the Results

The Problem

- The planning, monitoring and control of software development projects require that effort and costs be reliably estimated.
- Effort estimation still remains a challenge for practitioners and researchers.
- In 2005, ISBSG analyzed project duration, effort, cost and size estimates using the data from over 400 completed software projects;
  - Among those, effort attribute is found to be estimated worst.
  - It is found that:
    - Less than one quarter of projects are estimated accurately and on average the actual effort was about double the estimate.
    - About 60% of the projects underestimated effort by at least 10%.
    - Moreover, significant errors are observed; for instance, actual effort utilized has become 20 times the estimate.

The Problem (cont.)

- Effort estimation based on the functional size figures have just begun to emerge as more empirical data are collected in benchmarking datasets as in ISBSG dataset.
- Most of the studies focus on the project cost drivers and consider *total software functional size as the primary input* to estimation models.
  - Team Size (significant)
  - Business Area Type (significant)
  - Development Type (significant)
  - Application Type (significant)
  - Programming Language Type
  - Organization Type
- No model is considered to perform well enough to fully meet market needs and expectations.

Common Approach

- The effort estimation models take total functional size figure as the primary input.
- The functional size of a software product is a measure of the amount of functionality to be provided to the users.
  - Expressed as a single value obtained by a specific FSM method (IFPUG FP, COSMIC FP, MkII FP, etc.)
- This single value is derived from a measurement function defined in all FSM methods
  - Add functional sizes of different Base Functional Component (BFC) Types to obtain a total functional size.
  - BFC: is an elementary unit of a FUR defined by and used by an FSM method for measurement purposes.
  - BFC Type: A defined category of BFCs.

Background work

- Abran et al. (2003):
  - Proposed the concept of software functional profile as the distribution of function types within the software.
  - Investigated IFPUG functional size-effort relationship considering the average functional profile of the sample studied.
  - For each sample, there was one function type that had a stronger relationship with project effort.
- Abran and Panteliuc (2007):
  - Investigated the impact of the functional profile on COSMIC functional size – effort relationship.
  - Observed that the identification of the functional profile of a project and its comparison with the profiles of their own samples can help in selecting the best estimation models.
- Gencel (2005):
  - Identified the types of functionalities a software system can provide to its users defined a multidimensional measure which involves measuring the functional size of each.
  - The relationship between the functional size of each functionality type and the effort needed to develop the type of functionality that can pioneer new effort estimation methods.
- Gencel and Buglione (2007):
  - Made an analysis on the ISBSG dataset to test whether the effort required to develop the unit size of each of the BFC Types contributes to total effort at different levels.
  - The results showed that using the functional sizes of each BFC Type as inputs to effort estimation improve the estimation reliability.

Our Approach

- Our hypothesis:
  - The effort required to develop the unit size of each of the BFC Types (productivity values), which provide different functionalities to the users, is different.
- We explored whether effort estimation models based on the functional size of BFC Types, rather than the total functional size, improve estimation reliability.
  - Previous study: Form homogenous sub-groups of projects based on Application Type

Data Preparation

- Projects data from ISBSG 2007 Repository, CD Release 10.
- ISBSG Repository includes high-quality data about 4,106 projects.
- Among those, 117 projects were sized using COSMIC.
- The projects cover a wide range of applications, development techniques and tools, implementation languages, and platforms.
- We built a series of homogeneous subsets considering Development Type.

Step	Attribute	Filter	Projects Excluded	Remaining Projects
1	Count Approach[1]	= COSMIC-FFP	3,989	117
2	Data Quality Rating (DQR)	= {A | B}	5	112
3	Quality Rating for Unadjusted Function Points (UFP)	= {A | B}	21	91
4	Development Type	= {New Development}	22	34
		= {Enhancement}		30
		= {Re-development}		5

Filtration of ISBSG 2007 Dataset Release10

- First, sub-datasets are analyzed to determine the strength of the relationship between the total functional size and the development effort
  - Linear Regression Analysis method
- Next, the strength of the relationship between the functional sizes of the COSMIC BFC Types and development effort is analyzed
  - Multiple Regression Analysis method
- Then, the findings are compared.
- The distribution of different BFC Types in different Application Types are also investigated.

Statistical Data Analysis

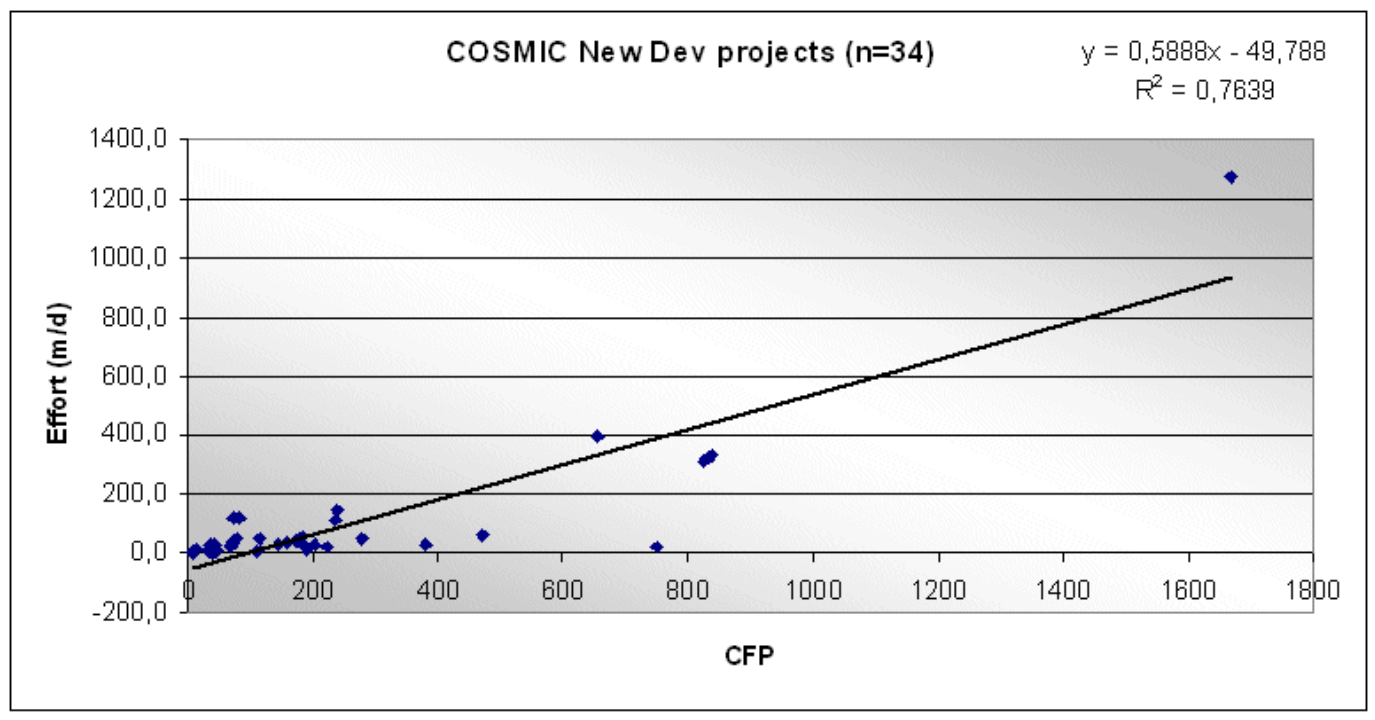
- All the statistical data analyses were performed with the GiveWin 2.10 tool and MS Excel 'Data Analysis ToolPak'
- Linear/Multiple Regression Analysis performed
  - Independent variable: Functional Size / Functional Sizes of BFC Types
  - Dependent variable: Normalized Work Effort
- A significance test is carried out in building a linear regression model.
  - This is based on a 5% level of significance.
- An F-test is performed for the overall model.
  - A (Pr > F) value of less than 0.05 indicates that the overall model is useful.
  - That is, there is sufficient evidence that at least one of the coefficients is non-zero at a 5% level of significance.
- A t-test is conducted on each βj ($0 \leq j \leq k$).
  - If all the values of (Pr > |t|) are less than 0.05, then there is sufficient evidence of a linear relationship between y and each xj ($1 \leq j \leq k$) at the 5% level of significance.

Total Functional Size - Effort Relationship

- For the Linear Regression Analysis;
  - Independent variable: Functional Size
  - Dependent variable: Normalized Work Effort (NW_Effort)

$$NW\_Effort = B_0 + B_1 FunctionalSize$$

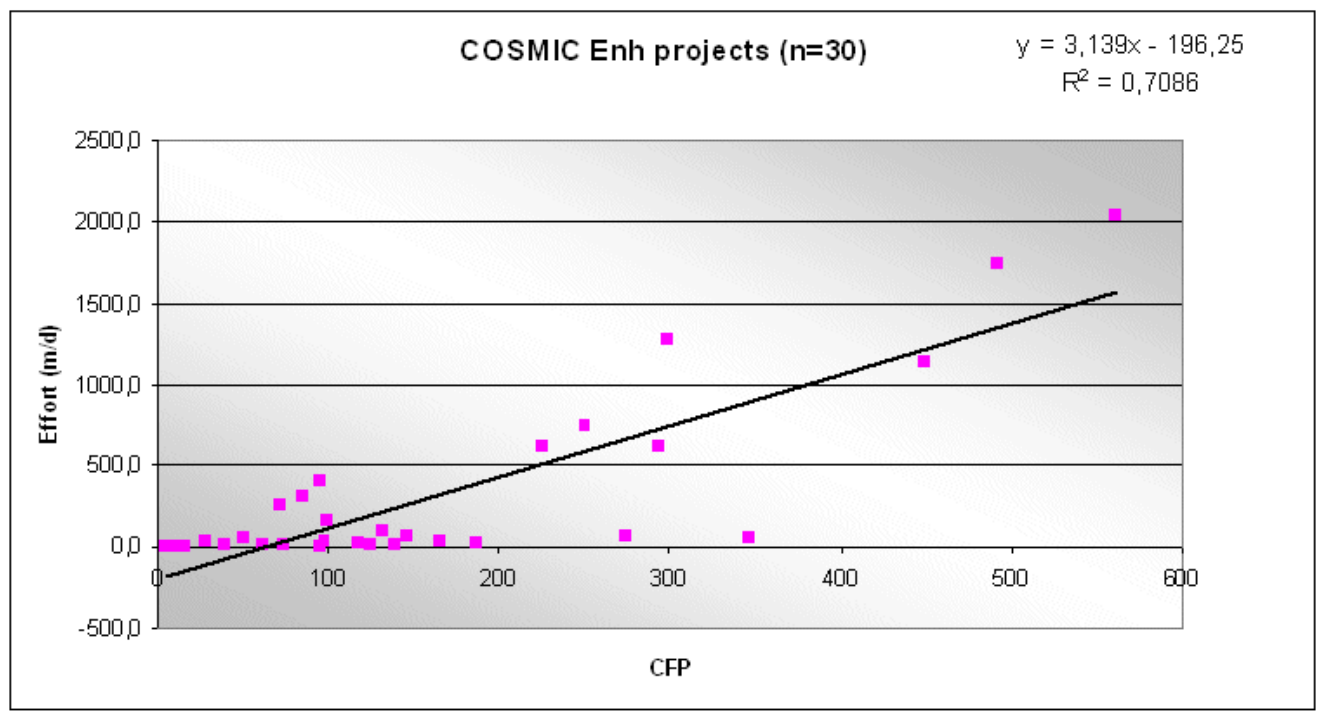
Linear Regression Analysis



n= 34

R^2= 0.76

Sub-dataset 1: New Development



n= 30

R^2=0.71

Sub-dataset 2: Enhancement

Subset 1: New Development Projects

	Coeff	StdError	t-value	t-prob	Split1	Split2	reliable
Constant	-49.78763	24.48831	-2.033	0.0504	0.0363	0.4419	0.7000
Functional Size	0.58882	0.05787	10.174	0.0000	0.0000	0.0000	1.0000

R^2 = 0.7639

	value	prob
normality test	28.5832	0.0000

Subset 2: Enhancement Projects

	Coeff	StdError	t-value	t-prob	Split1	Split2	reliable
Constant	-196.24813	83.73519	-2.344	0.0264	0.2963	0.0081	0.7000
Functional Size	3.13900	0.38040	8.252	0.0000	0.0004	0.0000	1.0000

R^2 = 0.7086

	value	prob
normality test	4.3408	0.1141

Regression Analysis Results (Normalized Work Effort – Total Functional Size)

Functional Sizes of COSMIC BFC Types – Effort Relationship

- The functional size in COSMIC is calculated by summing up the Entry (E), Exit (X), Read (R) and Write (W) data movement types.
- We used the following multiple linear regression model:

$$NW\_Effort = B_0 + B_1(E) + B_2(X) + B_3(R) + B_k(W)$$

- where *NW_Effort* (Normalized Work Effort) is the dependent variable and *E, X, R* and *W* are the independent variables.

Sub-dataset 1: New Development Projects dataset
Observations: 34

	Coeff	StdError	t-value	t-prob
Constant	-31.83818	18.46448	-1.724	0.0953
E	0.72694	0.38916	1.868	0.0719
X	0.01875	0.25507	0.073	0.9419
R	-0.03702	0.24675	-0.150	0.8818
W	2.21199	0.42239	5.237	0.0000

R^2 = 0.8919

	value	prob
normality test	13.2388	0.0013

After F presearch testing,

	Coeff	StdError	t-value	t-prob	Split1	Split2	reliable
Constant	-32.10285	17.75256	-1.808	0.0803	0.1592	0.0360	0.7000
E	0.74298	0.23129	3.212	0.0031	0.0004	0.0000	1.0000
W	2.17018	0.30448	7.128	0.0000	0.0000	0.4214	0.7000

R^2 = 0.8918

Multiple Regression Analysis Results (Normalized Work Effort – Funct. Sizes of BFC Types)

Sub-dataset 2: Enhancement Projects Dataset
Observations: 30

	Coeff	StdError	t-value	t-prob
Constant	-46.26395	67.37480	-0.687	0.4986
E	-0.47787	1.91093	-0.250	0.8046
X	7.37899	1.40681	5.245	0.0000
R	-1.76768	1.35114	-1.308	0.2027
W	8.08448	2.59471	3.116	0.0046

R^2 = 0.8755

	value	prob
normality test	3.3048	0.1916

After F presearch testing, specific model of WE;

	Coeff	StdError	t-value	t-prob	Split1	Split2	reliable
X	7.61616	1.31971	5.771	0.0000	0.0000	0.0000	1.0000
R	-2.51783	0.99965	-2.519	0.0180	0.1747	0.0129	0.7000
W	7.55544	2.47507	3.053	0.0050	0.1043	0.0058	1.0000

R^2 = 0.8713

Multiple Regression Analysis Results (Normalized Work Effort – Funct. Sizes of BFC Types)

- The R^2 statistics derived for the two approaches are compared.

Sub-datasets	# of Data Points	R^2 (Using Total Functional Size (CFP))	R^2 (Using BFC Types)	Increase[2] (%)
Sub-dataset 1: New Development	34	0.76	0.89	+16.7%
Sub-dataset 2: Enhancement	30	0.71	0.88	+23.6%

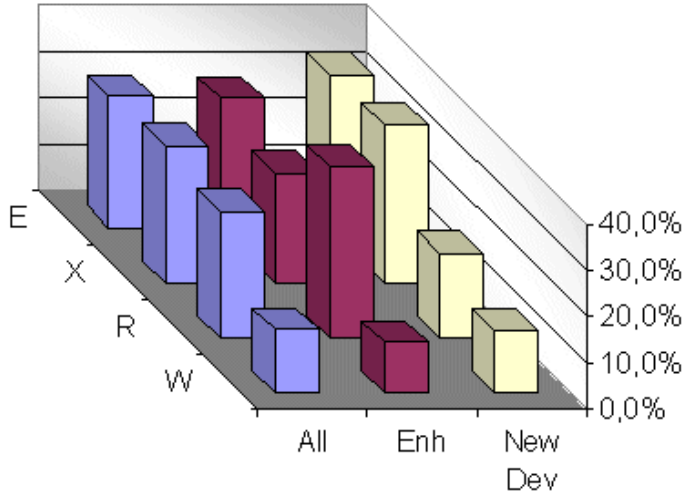
- The results showed a significant improvement in the modeling of the size-effort relationship in the estimation models for both sub-data sets.
- An interesting observation is that not all BFC Types found to be significant in estimating effort:
  - Entry and Write for New Development projects
  - Exit, Read and Write for Enhancement projects

Discussion of the Results (I)

		R^2	ESTIMATION FORMULA
Sub-dataset 1: *New Development Projects (n=34)*	Total functional size (CFP)	0.7639	*Y=0.5888*CFP-49.788*
	E/X/W/R	0.8919	*Y=0.72694*E+0.011875*X-0.03702*R+2.21199*W-31.83818*
	E/W	0.8918	*Y=0.74298*E+2.17018*W-32.10285*
Sub-dataset 2: *Enhancement Projects(n=30)*	Total functional size (CFP)	0.7086	*Y=3.139*CFP-196.25*
	E/X/W/R	0.8755	*Y=-0.47787*E+7.37899*X-1.76768*R+8.08448*W-46.26395*
	X/R/W	0.8713	*Y=7.61616*X-2.51783*R+7.55544*W*

Estimation Models

- Next question: Is there a correlation between the contribution of BFC Types to total functional size and the BFC Types which are found to be significant in estimating the effort?



	E	X	R	W
All	28,6%	29,8%	27,5%	13,7%
Enh	28,1%	23,8%	37,1%	11,0%
New Dev	33,4%	34,3%	18,3%	13,4%

Discussion of the Results (II)

- The contribution to total functional size to Enhancement projects
  - **E** and **X** types contribute more in New Development projects
  - **R, E, X** types contribute more in Enhancement Projects
- The BFC Types which are significant in effort estimation;
  - **E** and **W** types for New Development projects
  - **X,R,W** types for Enhancement Projects
- No significant correlation!

Conclusions & Prospects

- The effort required to develop software for different functional domains might be better explained by taking into account the functional sizes of different BFC Types.
- We need to consider the level of contribution of different functionality types to total effort rather than relying on an average functional profile.
- More research is needed to analyze the effect of different BFC Types – functionality types - on effort estimation.
- Empirical studies are needed to identify differences between the productivity values for developing different functionalities
  - A new representation of size as a vector of measures instead of a total figure is promising!

Thank you very much!

cigdem.gencel@bth.se
luigi.buglione@eng.it