

# Advances in statistical analysis from the ISBSG benchmarking database

GUFPI-ISMA SBC (Software Benchmarking Committee)

Participating authors: Luca Santillo, Stefania Lombardi, Domenico Natale

## Abstract

*This work presents statistical analyses of adequate sub-samples of development and enhancement software projects extracted from the ISBSG Benchmark 8 (International Software Benchmarking Standards Group, 2003). This research is an incremental process based on the voluntary participation of the members of the Software Benchmarking Committee of the Italian Software Metrics Association (GUFPI-ISMA SBC). The research mainly focuses on the distribution of the project in the ISBSG sample with regard to: functional size method, project size, completion date, development platform, work effort & productivity, primary programming language, and project solar duration. Specific data selection, filtering and transformation criteria are explained and applied. Correlation analysis is proposed – wherever significant – in order to suggest possible utilizations in the field of software estimation. Some suggestions arise from this research in order to achieve an effective data collection by any organization within its own benchmarking database.*

## 1. Introduction

GUFPI-ISMA is a non-profit organization, whose mission is to promote and encourage the use of software measurement methods in Italy [1]. The GUFPI-ISMA Software Benchmarking Committee (SBC), under the guidance of Domenico Natale and Luca Santillo, is aimed to study methods and techniques to analyse and compare software performances, with special attention to software productivity and cost [2]. In the second half of 2003, the GUFPI-ISMA SBC started a series of analysis on the ISBSG Benchmark (Release 8, February 2003) – a database of over 2,000 software development and enhancement projects collected by the ISBSG [5]. Similar analyses have been already performed by ISBSG or others – the SBC's aim is to diffuse, extend, validate and enhance such kind of analysis.

In the current work phase, a subset of main variables was extracted and analysed; the chosen variables are: *measurement method, project type, project size, development platform, completion date, work effort, project delivery rate, and programming language*. Further analyses will take into account more variables and eventually more possible correlations and regression will be investigated and reported in future publications by the SBC. Although this is just the first step of the SBC's analysis plan, some suggestions already arise in order to improve and enhance the collection and presentation of the benchmarking data, in order to provide more effective and complete analysis results, in terms of both quality and quantity.

*GUFPI-ISMA SBC analyzes ISBSG and other benchmarking data with the intent of better understanding their meaning, usefulness and consistency. The results of such analysis are not to be considered as a valid reference for any possible official, commercial or legal utilization. Neither GUFPI-ISMA, nor the authors can be hold responsible for errors or damages coming form external utilization of their analysis results.*

## 2. Demographic overview of the ISBSG Benchmark 8

The SBC's analyses are performed on specific data subsets, selected by means of filters to represent significant information. Throughout the paper, graphs and tables are presented – with the number of projects involved – in order to report some key statistics of selected variables. Variables not explicitly involved in the analyses are not described in further details. Table 1 below describes a reduced set of variables from the ISBSG Benchmark 8 database (the “value range” column is the number of different value instances, not the list of such values); a complete table with all the 66 ISBSG variables and a discussion of their interpretation and completeness, along with suggestions for their collection improvement can be found in the work describing the previous, first step of the SBC analysis [3].

The projects origin is not reported by ISBSG, for anonymity reasons. According to ISBSG, major contributors are: Australia, Japan, the United States, the Netherlands, Canada, and United Kingdom; among smaller contributors: India, France, Brazil, and others [5].

*Table 1. Relevant variables in the ISBSG benchmarking sample (extract).*

Variable	ISBSG Name	N	%	Type	Range	Multiple	Calc
DQR	Data Quality Rating	2,027	100.0%	Ord.	4		
MM	Count Approach	2,024	99.9%	Text	14		
FP_STD_PRIMARY	FP Standard	1,938	95.6%	Text	25		
WE_TOT	Summary Work Effort	2,025	99.9%	Num.	-		
RL	Resource Level	2,027	100.0%	Ord.	4		
MTS	Max Team Size	1,015	50.1%	Num.	-		
PRJ_TYPE	Development Type	2,027	100.0%	Text	5		
PLATFORM	Development Platform	1,418	70.0%	Text	3		
LANG	Programming Language	1,691	83.4%	Text	122	Yes	
DT	Development Techniques	1,025	50.6%	Text	227	Yes	
PRJ_TIME	Project Elapsed Time	1,639	80.9%	Num.	-		
PRJ_ITIME	Project Inactive Time	701	34.6%	Num.	-		
IMPL_DATE	Implementation Date	1,802	88.9%	Date	-		
PACKAGE	Package Customisation	1,322	65.2%	Y/N	3		
PRJ_SCOPE	Project Scope	1,275	62.9%	Text	26	Yes	
WE1P	WE Plan	957	47.2%	Num.	-		
WE2S	WE Spec	1,180	58.2%	Num.	-		
WE4B	WE Build	1,291	63.7%	Num.	-		
WE5T	WE Test	1,245	61.4%	Num.	-		
WE6I	WE Impl	846	41.7%	Num.	-		
FP_EI/EO/EQ	I/O/Inquiry count (x3)	2,027	100.0%	Num.	-		
FP_ILF/EIF	Int./Ext. Files count (x2)	2,027	100.0%	Num.	-		
FP_ADD/CHG/DEL	Adds/Changes/Del's (x3)	2,027	100.0%	Num.	-		
WE_NORM	Normalised Work Effort	2,024	99.9%	Num.	-		Yes
UFP	Unadjusted Size (FP)	1,568	77.4%	Num.	-		Part.
UFP_RAT	Size Rating	2,027	100.0%	Ord.	4		Yes
PDR	Project Delivery Rate	1,569	77.4%	Num.	-		Yes
PDR_NORM	Normalised PDR	1,569	77.4%	Num.	-		Yes

## 2.1. Analysis of variables collection

In the previous step of the analysis [3], each of the 66 variables - collected by means of questionnaires by ISBSG – have been analysed. A list of comments on observed data was achieved, in order to improve the collection quality and usefulness. Mostly, comments refer to missing values, ambiguous values and misuse of textual values. Some data manipulations were performed to resolve some of the critical aspects:

- *dichotomization* (from multiple combinations of values to multi-column binarization);
- *nomenclature fixing* (for textual variables).

## 2.2. Overall values distributions for selected variables

The selected variables for the analyses by SBC are: size (UFP), work effort (WE\_TOT), project delivery rate (PDR), platform (PLATFORM), primary programming language (LANG), implementation date (IMPL\_DATE) and project solar duration (PRJ\_TIME).

Distribution analyses are reported for selected variables over the whole ISBSG sample. The following header is common to the following tables:

N	%	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
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- **N** is the number of cases or data instances in the sample.
- **%** is the percent amount with respect to the sample.
- **Min** and **Max** are, respectively, the minimum and the maximum values in the sample.
- **Pxx** is the  $xx^{th}$  percentile (it is that value which is greater than the values of  $xx$  percent of the members of the sample); P25 is also known as the first quartile, P75 as the third quartile; the 50<sup>th</sup> percentile, or **Median**, divide the sample in two equal parts..
- **Mean** and **Std Dev** are, respectively, the arithmetic mean and the standard deviation.

Since many distributions are skewed towards low values – and the data contains outliers – the median is a more useful measure, with respect to the mean. The maximum value of N is 2,027, since this is the total number of project instances in the Benchmark 8 – but this amount is rarely reached, due to void, unknown, or unclear values. Next, basic distributions are reported, but no diagram is plotted, since no differentiation is made among distinct measurement methods and project types.

### *UFP (unadjusted function point size – measurement unit: UFP)*

N	%	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
1,568	77.4	6.0	63.0	109.8	224.0	476.0	1,182.2	19,050.0	514.2	1,087.3

### *WE\_TOT (summary work effort – measurement unit: ph)*

N	%	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
2,025	99.9	5.0	419.4	888.0	2,200.0	5,307.0	13,737.6	645,694.0	6,883.4	26,160.8

### *PDR (project delivery rate – measurement unit: ph/UFP)*

N	%	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
1,569	77.4	0.02	2.0	4.2	9.0	18.0	33.7	640.0	15.6	26.7

### *PLATFORM (development platform – textual variable)*

N	%	MF	%_N	MR	%_N	PC	%_N
1,418	70.0	844	59.5	252	17.8	322	22.7

Captions: MF = Mainframe, MR = Midrange, PC = Personal Computer

*LANG (primary programming language – textual variable)*

N	%	Cobol*	%_N	C	%_N	VB	%_N	C++	%_N	Oracle	%_N	Rest	%_N
1,691	83.4	451	26.7%	153	9.0%	115	6.8%	114	6.7%	108	6.4%	751	44.4%

*IMPL\_DATE (implementation date – date field)*

N	%	2002	%_N	2001	%_N	2000	%_N	1999	%_N	1998	%_N	Rest	%_N
1,802	88.9	147	8.2%	75	4.2%	387	21.5%	282	15.6%	236	13.1%	675	37.5%

*PRJ\_TIME (project solar duration – measurement unit: month)*

N	%	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
1,639	80,9	0,5	2,0	4,0	7,0	11,0	17,0	84	8,6	7,4

### 3. Subsets selection for analyses

In order to analyse the selected variables, some filtering and transformation actions had to be performed on the original ISBSG data sample, leading to two sub-samples, denoted as sample A (or “soft filter” sub-sample) and sample B (or “severe filter” sub-sample) [REF]; the criteria are briefly reported in Table 2. The current work reports the analysis results from the “severe filter” sample, only. The “project type” attribute has been kept in the sub-samples to differentiate the analysis results by project type: “Development” or “Enhancement”.

Note that filtering out records with PACKAGE = “Y” left records with both explicit “N” values and void values, so that a remaining impact of undocumented package customisation for some projects could still affect the analysis results.

*Table 2. Applied filters; starting N is 2,027.*

Step	Filtering Variable	Filtering Criteria	Excluded Records	Residual	Res. %
1	PRJ_TYPE	= “New Dev.” Or “Enh.”	57 (various)	1,970	97.2%
2	MM	= “IFPUG”	195 not “IFPUG”	1,775	87.6%
3	DQR	= “A” Or “B”	113 “C” or “D”	1,662	82.0%
4	FP_STD_PRIMARY	= “IFPUG *”	336 not “IFPUG *”	1,326	65.4%
<b>Ä Sample A (“soft filter” sub-sample; 1,326 records)</b>					
5	PACKAGE	≠ “Y”	68 “Y”	1,258	62.1%
6	UFP_RAT	= “A” Or “B”	185 “C” or “D”	1073	52.9%
7	FP_STD_PRIMARY	= “IFPUG 4.*”	159 unspecified or “< 4”	914	45.1%
8	RL	= “1” Or “2”	140 “3” or “4”	774	38.2%
<b>Ä Sample B (“severe filter” sub-sample; 774 records)</b>					

#### 3.1. Data categorization

Due to the wide variety of value instances, two variables have been “translated” into new category variables (or “classes”):

- IMPL\_DATE (Implementation Date), re-aggregated into IMPL\_PERIOD (Implementation Period); selected periods are non-overlapping: 1989-1990, 1991-1992, 1993-1994, ..., 1999-2000, 2001-2002. IMPL\_PERIOD is an indicator of “when the project was completed”, not of “when the project was executed”.
- PRIM\_PROG\_LANG (Primary Programming Language), re-aggregated into LANG\_LEV (Language Level), and further re-aggregated into LL\_CAT (Language Level Category);

Capers Jones' well-known programming languages table was taken as a reference for such classification (Table 3).

**Table 3. Programming languages (examples), level ranges and categories.**

LL_CAT	Range	Examples
LL_CAT 1	1-3	ASSEMBLER, C, COBOL, COBOL 2, MVS COBOL, FORTRAN, PASCAL.
LL_CAT 2	4-8	3 <sup>rd</sup> Gen. Lang, PL/I, LISP, C++, JAVA, ADA, CICS, ORACLE, MS ACCESS.
LL_CAT 3	9-15	VISUAL BASIC, DELPHI, LOTUS NOTES, UNIX SHELL SCRIPT [...].
LL_CAT 4	16-23	4 <sup>th</sup> Gen. Lang., CLIPPER, POWERBUILDER, TELON, SAP ABAP, HTML, ASP.
LL_CAT 5	24-55	SQL, EASYTRIEVE, PL/SQL, SQL WINDOWS, Spreadsheets.
LL_CAT 6	>55	5 <sup>th</sup> Generation Languages.

### 3.2. Data transformation

The only relevant data transformation taken by the SBC was:

- UFP size attribute equalized to the (adjusted) FP values from the ISBSG database for those projects, where only “FP”, with no “VAF” and no “function breakdown detail”, was provided; analysing further data only by means of size ranges – see next section 4 – can smooth the risk carried by this hypothesis;
- PDR re-calculated by SBC, including previously void values where UFP is achieved (previous item).

### 3.3. Values distributions in final sub-samples

Sample A (“soft filter” sub-sample) and sample B (“severe filter” sub-sample) were obtained through the previously depicted filtering, categorization and transformation actions; they contain, respectively, 65.4% and 38.2% of the original ISBSG database recordset. The sub-sample B characteristics are reported in the following Table 4, where:

- “DEV” and “ENH” stand, respectively, for “(new) development” and “enhancement” (project type) - “Aggr.” stands for “Aggregated”;
- “PRJ\_ID” is omitted, but still present for sake of traceability of records;
- percentages are referred to the sub-sample, by column, – not to the overall database;
- aspects that remained critical are highlighted in grey;
- aspects that were improved are highlighted with bold, italic text style.

Note that no variable in this sub-sample has multiple values.

**Table 4. Characteristics of selected variables in sample B (“severe filter”).**

Variable	N	%	N <sub>DEV</sub>	% <sub>DEV</sub>	N <sub>ENH</sub>	% <sub>ENH</sub>	Type	Range	Calc
UFP	774	[100%]	299	[100%]	475	[100%]	Num.	-	Part.
PLATFORM	386	49.9	168	56.2%	217	45.7%	Text	3	
LANG_LEV	587	75.8	214	71.6%	373	78.5%	<b>Ord.</b>	<b>29</b>	Aggr.
LANG_CAT	587	75.8	214	71.6%	373	78.5%	<b>Ord.</b>	<b>6</b>	Aggr.
IMPL_PERIOD	719	<b>92.9</b>	270	90.3%	449	94.5%	<b>Ord.</b>	<b>6</b>	Aggr.
WE_TOT	774	<b>100.0%</b>	299	100.0%	475	100.0%	Num.	-	
PDR	774	<b>100.0%</b>	299	100.0%	475	100.0%	Num.	-	Yes

#### 4. Distribution analyses

**UFP (unadjusted function point size – measurement unit: UFP) – Sample B.**

	N	%	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
DEV	299	38.6%	25.0	112.0	174.5	<b>334.0</b>	676.0	1,438.4	16,148.0	666.5	<b>1,227.8</b>
ENH	475	61.4%	6.0	56.0	88.0	<b>153.0</b>	281.0	604.4	7,134.0	282.2	<b>470.4</b>
<b>TOT</b>	<b>774</b>	<b>100%</b>	<b>6.0</b>	<b>63.0</b>	<b>108.3</b>	<b>201.5</b>	<b>429.8</b>	<b>928.3</b>	<b>16,148.0</b>	<b>430.6</b>	<b>867.1</b>

From the analysis of percentiles on the logarithmic distribution for development and enhancement projects (separately), a limited set of project size classes is obtained (Table 5). Such classes are used for categorization of subsequent two-variable analyses; they are proposed for standardized use in agreement definitions and software estimation approaches.

**Table 5. Development and enhancement projects size classes.**

SIZE_CLASS	Dev Code	DEV UFP Range	ENH Code	ENH UFP Range
Very Small	DEV <sub>XS</sub>	0-150	ENH <sub>XS</sub>	0-60
Small	DEV <sub>S</sub>	150-300	ENH <sub>S</sub>	60-120
Medium	DEV <sub>M</sub>	300-600	ENH <sub>M</sub>	120-240
Large	DEV <sub>L</sub>	600-1,200	ENH <sub>L</sub>	240-480
Very Large	DEV <sub>XL</sub>	1,200-5,000	ENH <sub>XL</sub>	480-2,000
Extremely Large	DEV <sub>XXL</sub>	> 5,000	ENH <sub>XXL</sub>	> 2,000

**WE\_TOT (summary work effort – measurement unit: ph) – Sample B.**

	N	%	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
DEV	299	38.6%	50.0	597.6	1,057.5	2,540.0	5,924.0	14,911.8	73,920.0	6,232.1	<b>10,593.9</b>
ENH	475	61.4%	90.0	426.0	762.5	1,642.0	3,911.0	8,245.4	53,830.0	3,560.2	<b>5,607.1</b>
<b>TOT</b>	<b>774</b>	<b>100%</b>	<b>50.0</b>	<b>455.5</b>	<b>867.5</b>	<b>1,913.5</b>	<b>4,713.5</b>	<b>10,023.3</b>	<b>73,920.0</b>	<b>4,592.3</b>	<b>8,014.9</b>

No specific consideration are reported for effort distributions. More significant information is expected from the project delivery rate (i.e. summary work effort by size – next).

**PDR (project delivery rate – measurement unit: ph/UFP) – Sample B.**

	N	%	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
DEV	299	38.6%	0.1	2.1	3.9	8.0	16.2	23.1	300.3	12.8	<b>21.5</b>
ENH	475	61.4%	0.3	2.5	4.8	11.0	23.0	44.6	327.4	19.8	29.1
<b>TOT</b>	<b>774</b>	<b>100%</b>	<b>0.1</b>	<b>2.3</b>	<b>4.3</b>	<b>9.5</b>	<b>19.3</b>	<b>36.0</b>	<b>327.4</b>	<b>17.1</b>	<b>26.6</b>

As for the size and effort distribution, a skewed distribution is observed for project delivery rate. A log-normal distribution should be considered.

**PLATFORM (development platform – textual variable) – Sample B.**

	N	%	MF	%_N	MR	%_N	PC	%_N	Check
DEV	168	43.6%	98	58.3%	34	20.3%	36	21.4%	100%
ENH	217	56.4%	196	90.3%	9	4.2%	12	5.5%	100%
<b>TOT</b>	<b>385</b>	<b>100%</b>	<b>294</b>	<b>76.3%</b>	<b>43</b>	<b>11.2%</b>	<b>48</b>	<b>12.5%</b>	<b>100%</b>

Although the platform distributions are clear enough, some difficulty is found in interpreting the assignment of such values (e.g. “midrange” versus “personal computer” for some application types).

***LL\_CAT (language level category – ordinal variable) – Sample B.***

	N	%	LLC1 %_N	LLC2 %_N	LLC3 %_N	LLC4 %_N	LLC5 %_N	LLC6 %_N	Check
DEV	214	36.5%	98 45.8%	38 17.8%	28 13.1%	28 13.1%	22 10.3	0 0%	100%
ENH	373	63.5%	195 52.3%	102 27.3%	34 9.1%	27 7.2%	14 3.8%	1 0.3%	100%
<b>TOT</b>	<b>587</b>	<b>100%</b>	<b>293 49.9%</b>	<b>140 23.9%</b>	<b>62 10.6%</b>	<b>55 9.4%</b>	<b>36 6.1%</b>	<b>1 0.2%</b>	<b>100%</b>

The Language Level Category distribution has its maximum at LLC1 (Language Level 1-3), followed by LLC 2 (Language Level 4-8). A more specific analysis (not reported here) shows a peak for Level 3 languages (mostly COBOL). Many projects are present, where the Primary Programming Language is not provided.

***IMPL\_PERIOD (implementation period – ordinal variable) – Sample B.***

	N	%	1989-90	1991-92	1993-94	1995-96	1997-98	1999-2000	2001-02
DEV	270	37.6%	0	2	42	41	106	73	6
ENH	449	62.4%	0	0	10	24	163	95	157
<b>TOT</b>	<b>719</b>	<b>100%</b>	<b>0</b>	<b>2</b>	<b>52</b>	<b>65</b>	<b>269</b>	<b>168</b>	<b>163</b>

No specific distribution is expected for implementation period..

***PRJ\_TIME (project solar duration – measurement unit: month) – Sample B.***

	N	%	Min	P10	P25	Median	P75	P90	Max	Mean	Std Dev
DEV	264		0,5	3,0	5,0	7,0	13,0	20,0	44,0	9,7	6,8
ENH	309		1,0	2,0	4,0	6,0	9,0	13,0	27,0	6,9	4,4
<b>TOT</b>	<b>573</b>		<b>0,5</b>	<b>3,0</b>	<b>4,0</b>	<b>7,0</b>	<b>10,0</b>	<b>16,0</b>	<b>44,0</b>	<b>8,2</b>	<b>5,8</b>

As for the size, effort, and productivity distribution, a skewed distribution is observed for project solar duration. A log-normal distribution should be considered. Further analysis should consider the project *inactive* time.

## 5. Correlation analysis

A Pearson correlation table is reported for selected numerical variables [8].

	<i>DEV (N = 264)</i>				<i>ENH (N = 309)</i>			
	<i>UFP</i>	<i>WE_TOT</i>	<i>PDR</i>	<i>PRJ_TIME</i>	<i>UFP</i>	<i>WE_TOT</i>	<i>PDR</i>	<i>PRJ_TIME</i>
<i>UFP</i>	1,00	0,71	-0,07	0,36	1,00	0,40	-0,14	0,21
<i>WE_TOT</i>	0,71	1,00	0,32	0,65	0,40	1,00	0,30	0,21
<i>PDR</i>	-0,07	0,32	1,00	0,28	-0,14	0,30	1,00	0,10
<i>PRJ_TIME</i>	0,36	0,65	0,28	1,00	0,21	0,21	0,10	1,00

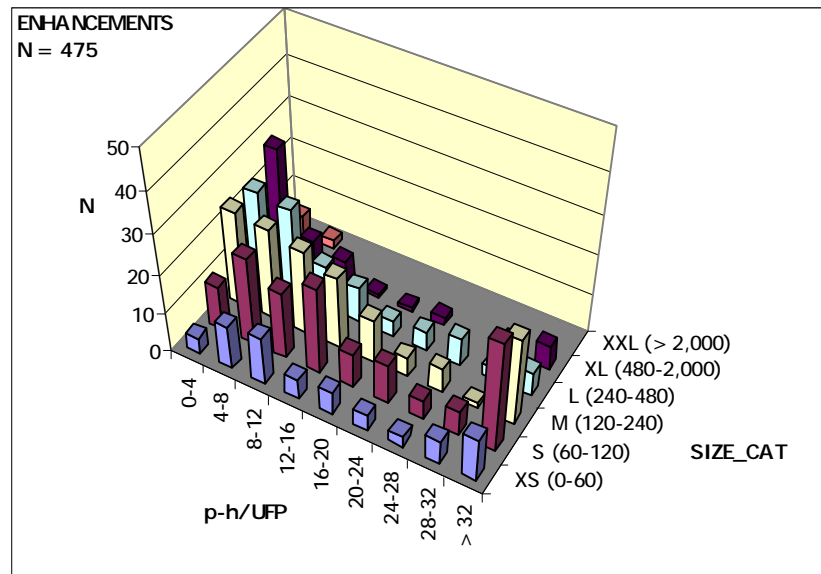
We can argue a moderate correlation between size and effort for new developments, while the same does not hold true for enhancements. One possible explanation is that the IFPUG size for enhancements includes the entire functions impacted, not only their modified portions. Also, for developments, a linear regression cannot be considered ( $r^2 = 0,5$ ), but a significance test yields positive for the correlation.

This initial correlation analysis confirms that the (functional) size is a primary cost driver for the project, but not the only one. Since the best fitting relationships among such variables have already been proved to be non-linear, further analysis is required, replacing linear correlation with other indicators and/or looking for multivariate relations.

## 6. Two-variables analyses

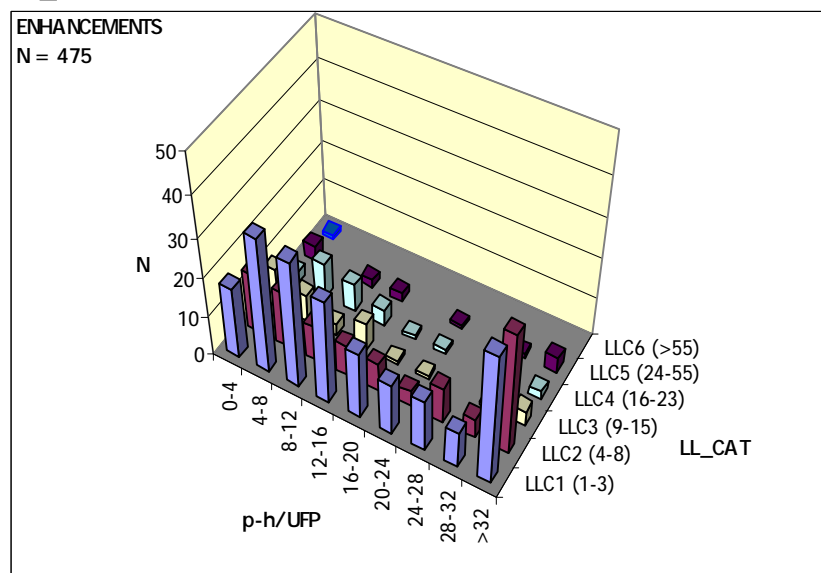
Two-variables analysis is introduced to investigate the dependency of PDR against other variables in a visual approach. Numerical regression analysis is omitted, by now, to avoid a potential misuse of the analysis results. Only enhancement cases are reported.

### 6.1. PDR vs. SIZE\_CLASS



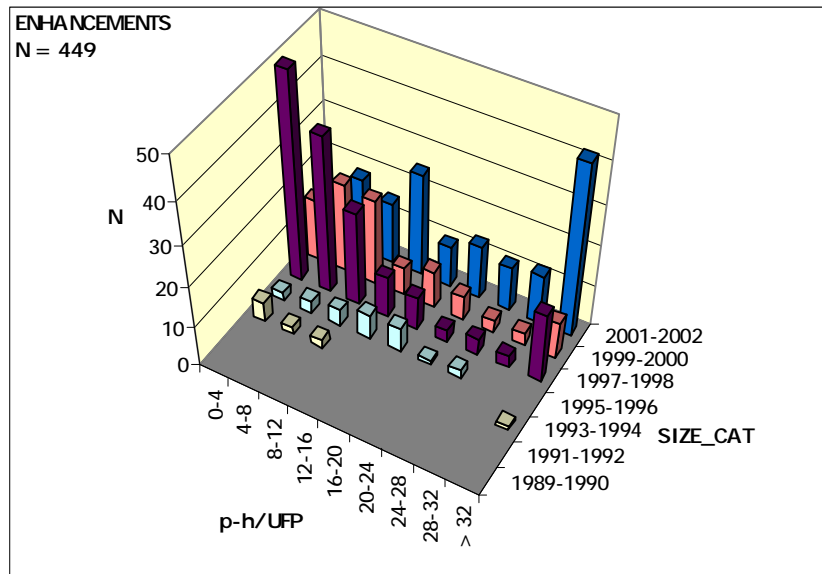
*Figure 1. PDR distributions against Size Class (Sample B). Although some log-normal trends could be perceived, more data could provide more regular distributions. Peak frequency values are between 4 and 12 person-hours per UFP (8 p-h » 1 person-day).*

### 6.2. PDR vs. LL\_CAT



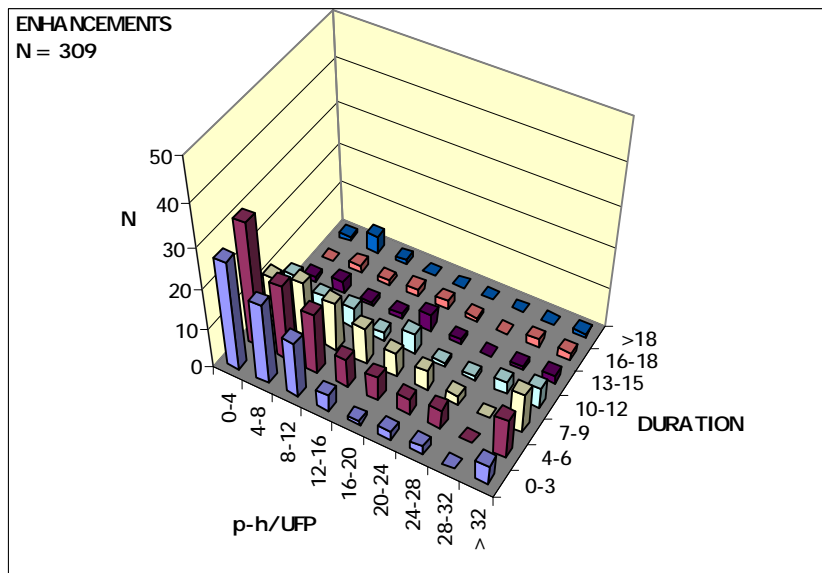
*Figure 2. PDR distributions against Language Level Category (Sample B). As easily argued, most enhancement projects are implemented with low level programming languages. The peak for PDRs' > 32 p-h/UFP is due to a tail containing high values.*

### 6.3. PDR vs. IMPL\_PERIOD



*Figure 3. PDR distributions against Implementation Period (Sample B). The PDR distribution in recent years (2001-2002) has a peak for PDRs' > 32 p-h/UFP, due to a tail containing several extremely high values.*

### 6.4. PDR vs. PRJ\_TIME



*Figure 3. PDR distributions against Project Solar Duration (Sample B). As expected, most of the enhancement projects has a limited duration (time-to-market reasons). A log-normal distribution could be argued; more data, or different categorization, is required.*

## 7. Conclusions

Several suggestions had been highlighted throughout the previous step of benchmarking analysis by the GUFPI-ISMA SBC:

- dichotomization (to avoid multiple values per record);
- nomenclature (to avoid distinct values for identical instances);
- taxonomy (to avoid open ranges – including a single “other” exception);
- completeness (to avoid excessive sample filtering, or interpretation of void values);
- variable categorization (to avoid excessive variety of instances).

While these suggestions may be considered for future improvements of the ISBSG collection process, as well as for the implementation of any local benchmarking database within an organization, some useful hints can be obtained from the analysis of the current data. The ongoing analysis should provide a double-check, by means of distinct methods, of statistical relationships that can be found in literature or from the ISBSG publications.

Although some projects are present in the overall ISBSG sample with measurement method alternative to IFPUG, as COSMIC and MkII approaches, such sample were found too sparse to permit significant analyses. The next benchmarking database release by the ISBSG, the Benchmark 9 issued at the end of 2004 with over 3'000 projects, will open new views on different measurement methods and their application in the statistical analysis. Therefore, further research developments are:

- extension over larger samples, including new sizing methods;
- outliers analysis and possible deletion;
- extension over more variables (e.g. functional breakdown by function type and by enhancement operation type, work effort phase breakdown, differentiation by methodology, by software domain, etc.);
- two-variables and N-variables regression analysis;
- factor and principal component analysis.

The GUFPI-ISMA Software Benchmarking Committee wishes to thank all its members for providing useful hints and collaboration on the benchmarking analysis (previous step) and to encourage further research on this subject.

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