Testing Data Analytics & COSMIC Estimation Models

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About Amitysoft

Enterprise Solutions } ERP / HCM, Data Analytics, IoT

Enterprise Cyber Security, QA, CMMI / ISO { Advisory & Technical Services

Training } Testing , CMMI, Big Data, Info Security, ERP/HCM

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Topics

1. Testing for Quality?
2. Test Data Analysis
3. Estimation Models
4. COSMIC in Software Testing
5. Conclusion

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TESTING FOR QUALITY?

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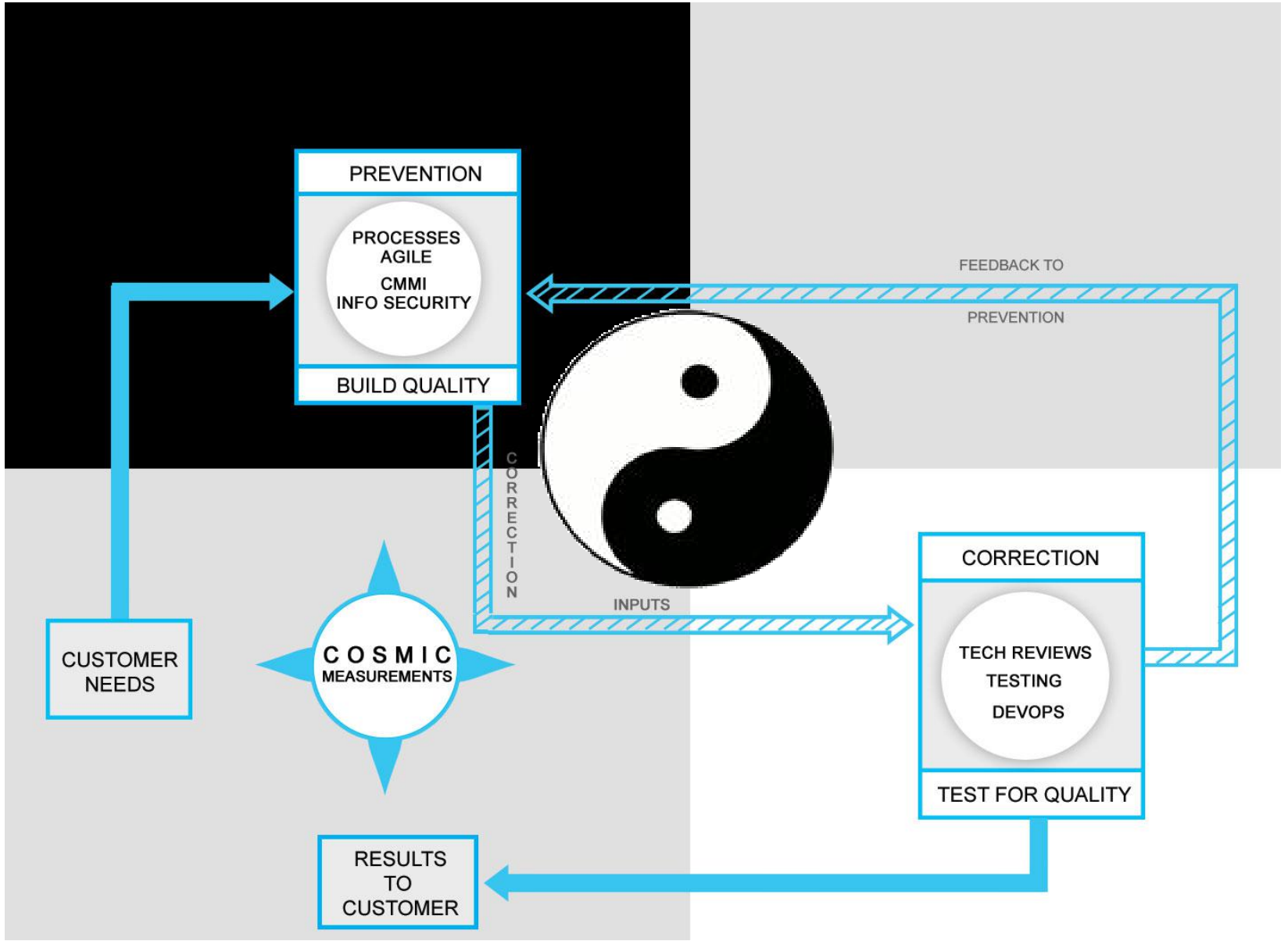

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TEST DATA ANALYSIS

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ISBSG Data for analysis

Release 12 of ISBSG data published in 2013 with a repository of 6006 projects.

Data used for Analysis

- ***Functional Size***: IFPUG Function Point (ISO 20296, 2009) or COSMIC Function Point (ISO 19761, 2011).
- ***Schedule, Team Size and Work Effort:*** project elapsed time, team size and work efforts for Plans, Specifications, Design, Build, Test and Install project phases.
- ***Project Processes:*** software life cycle activities followed - planning, specifications, design, build, test and usage of ISO 9001, CMMI, SPICE, PSP.

Data used for filtering

  - *Grouping Attributes* consisting Application Groups & Development type
  - *Development Platform* information such as PC, Mid-Range, Main Frame or Multi-Platform.
  - *Architecture information*
  - *Language Type* information
  - *Data Quality* Rating in terms of A, B, C or D

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Criteria for Data Selection

Data Quality:

- ISBSG Quality Rating
- Function Points Size Data

Data Relevance:

- Counting Method chosen should be either IFPUG 4+ or COSMIC FP results in Projects after year 2000.
- Client/ Server or Web based projects data were considered.

Data Suitability:

Testing efforts in overall development effort:

- Total normalized work effort is equal to or above 80 hours
- Efforts reported for testing is above or equal to 16 hours.

Data Adequacy:

- Application Group is chosen as 'Business Application'. Several projects are of Business Application category and this filter would result in larger data set.

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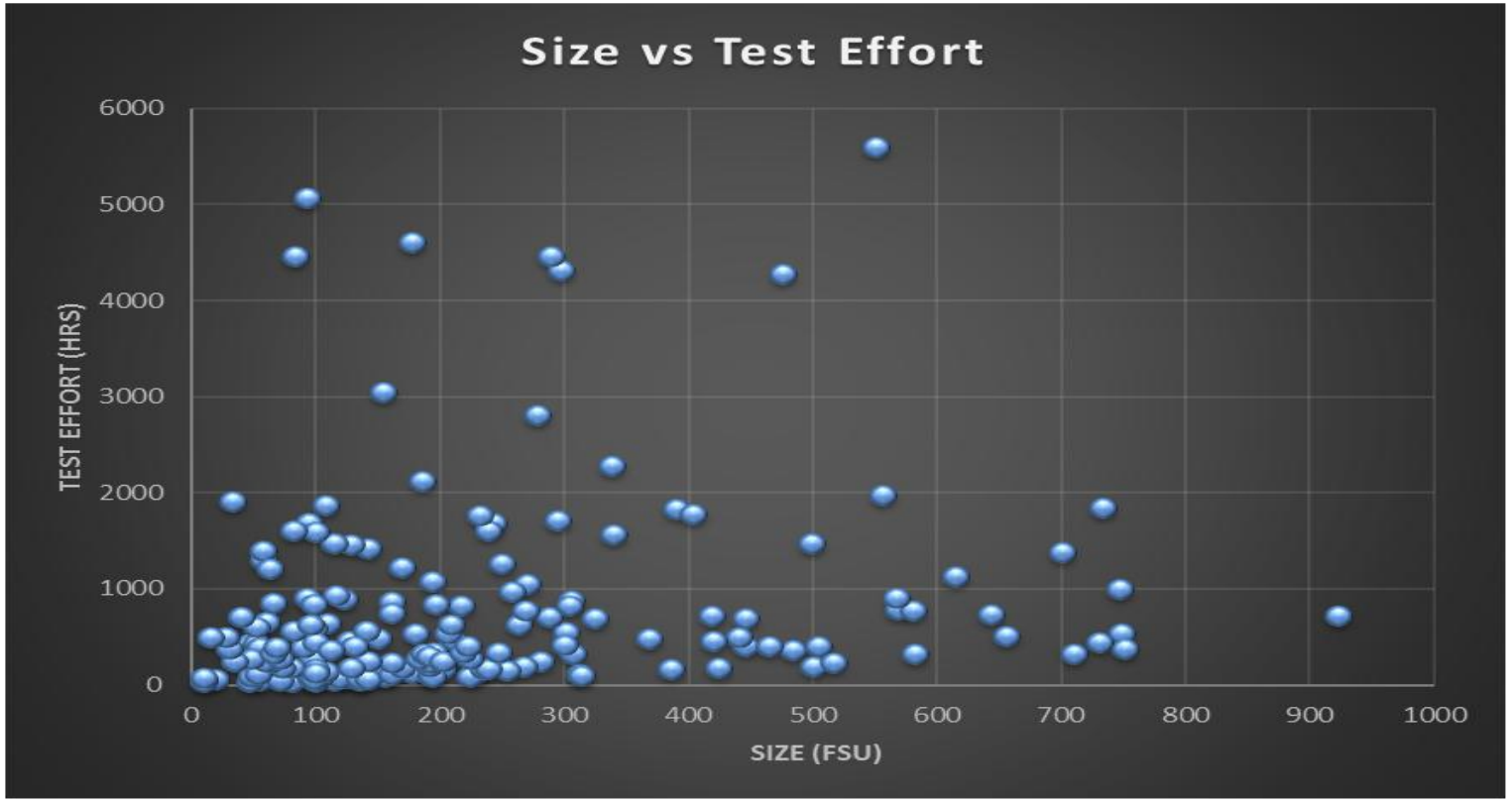
Size vs. Test Effort Scatter Diagram (N = 170)



- Presence of Multiple Models
- How do we recognize the Different models?
- Can Test Delivery Rate (TDR) provide clue?
- TDR measures the rate at which software functionality is tested as a factor of the effort required to do so. *(Expressed as Hours per Functional Size Unit (hr/ FSU).*

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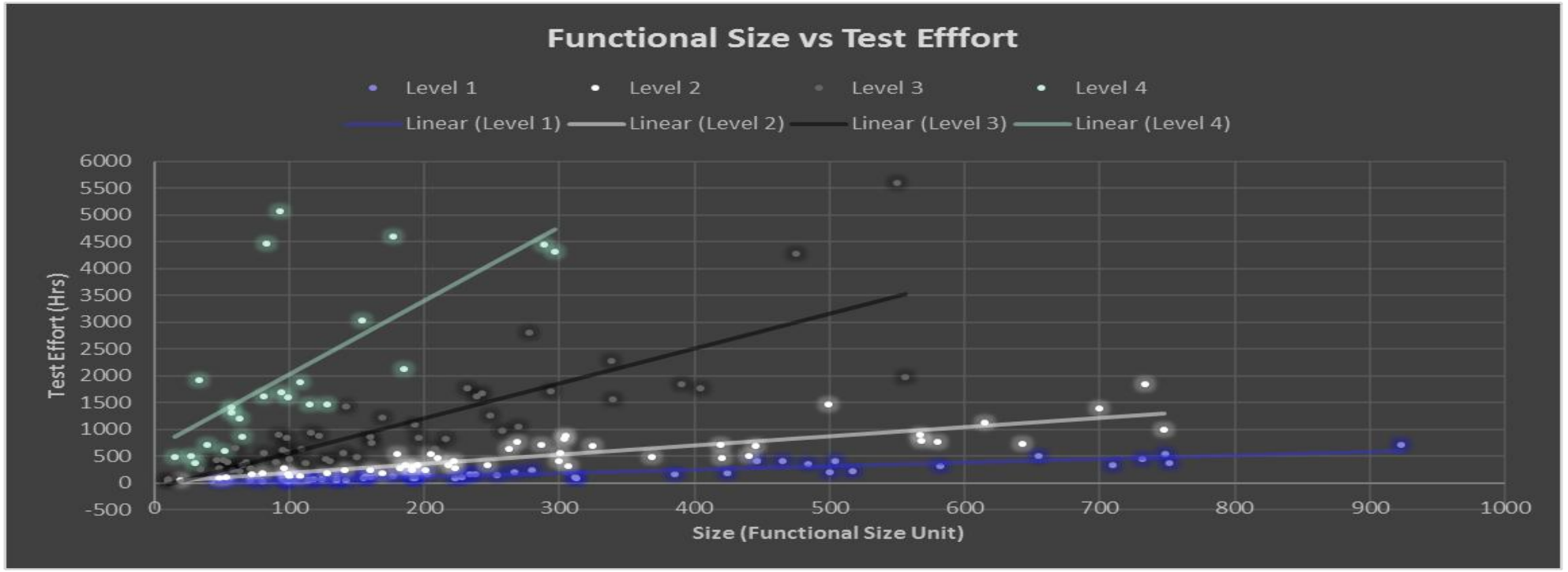
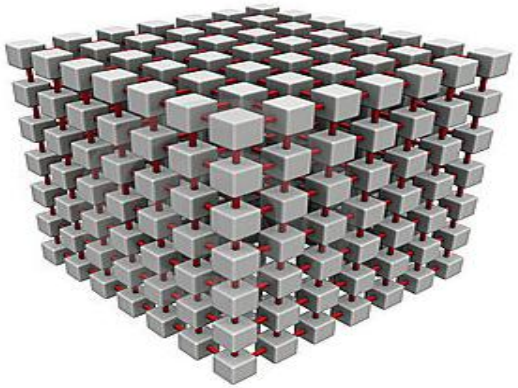
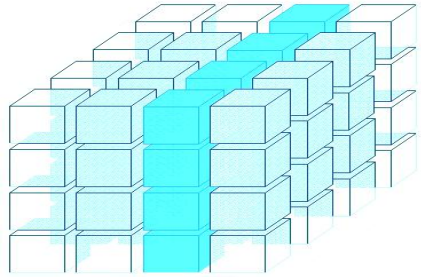
Data Set A: Slice and Dicing of Data: Economies of Scale





TDR Level	TDR (hr/ FSU)						
	Min	P10	P25	P50	P75	P90	Max
ALL	0.31	0.49	0.87	2.28	6.29	14.90	57.97
1	0.31	0.37	0.44	0.60	0.75	0.87	0.99
2	1.04	1.14	1.34	1.67	2.33	2.87	2.97
3	3.04	3.52	4.00	5.61	7.23	8.71	10.88
4	11.47	11.48	13.15	18.26	24.60	54.23	57.97



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If TDR is the ‘Effect’ What are the causes?

Domain	No./ %	PG 1	PG 2	PG 3	Team Size	No./%	PG 1	PG 2	PG 3
BFSI	No	14	23	32	Small	No	10	4	2
	%	20	33	46		%	63	25	13
Education	No	11	0	0	Medium	No	18	14	7
	%	100	0	0		%	46	36	18
Govt.	No	6	10	2	Large	No	5	4	8
	%	33	56	11		%	29	24	47
Elapsed Time	**No./ %**	**PG 1**	**PG 2**	**PG 3**	**V & V Rigour**	**No./%**	**PG 1**	**PG 2**	**PG 3**
Small	No	18	7	5	Low	No	25	42	43
	%	60	23	17		%	23	38	39
Medium	No	6	8	7	High	No	21	7	4
	%	29	38	33		%	66	22	13
Large	No	14	20	16					
	%	28	40	32					

Team Size – Number of team members

Elapsed Time is Project Elapsed Time in months;

V & V Rigour derived from ‘Documents & Techniques’ field to identify rigour of Verification & Validation activities;

Domain is Application Domain of software

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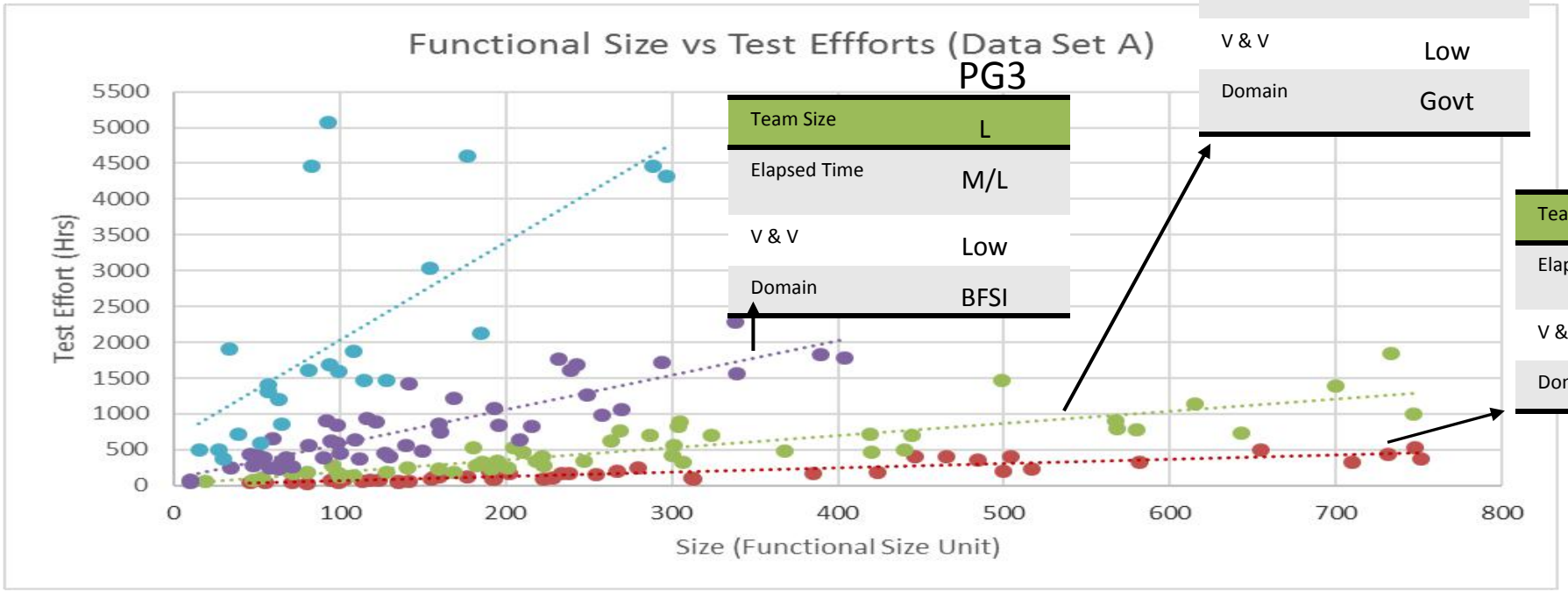
Models & Project Characteristics – Economies of scale



PG2

Team Size	S/M
Elapsed Time	M/L
V & V	Low
Domain	Govt

PG3

Team Size	L
Elapsed Time	M/L
V & V	Low
Domain	BFSI

PG1

Team Size	S/M
Elapsed Time	S
V & V	High
Domain	Edu

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Emergence of three distinct project groups

	Attribute	PG1	PG2	PG3
Causes	**Domain**	Educational	Government	BFSI
	Team Size	Small/ Medium	Small/ Medium	Large
	Elapsed Time	Small	Medium/ Large	Medium/ Large
	V & V Rigour	High	Low	Low
Effect	TDR	< 1 hr/FSU	1 – <3 hr/FSU	3 – 11 hr/FSU

Attribute/ Statistical Test	Team Size	Elapsed Time	V & V Rigour	Domain
Chi-Square	0.088	0.057	< 0.001	< 0.001
P Value				

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Process Quality as additional independent variables

Development Process Quality Rating (DevQ)

Project Attributes of interest:

- Standards followed,
- Distinct development life cycle phases followed, and
- Verification activities carried out during development.

Software Process	Documents & Techniques	DevQ Rating
Not reported	Very little reporting to infer	0
Reported	Very little reporting to infer	1
Not reported	One or more phases has values	1
Reported	One or more phases has values	2

Test Process Quality Rating (TestQ):

Project attributes of interest:

Testing techniques, test cases, levels of testing carried out.

Test Process Criteria	Test Process Rating (TestQ)
No evidence of Test Artefacts	0
Evidence of Test Artefacts	1

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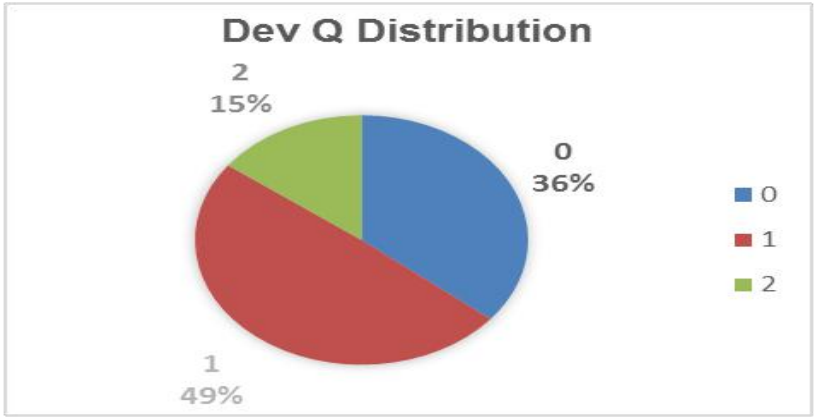
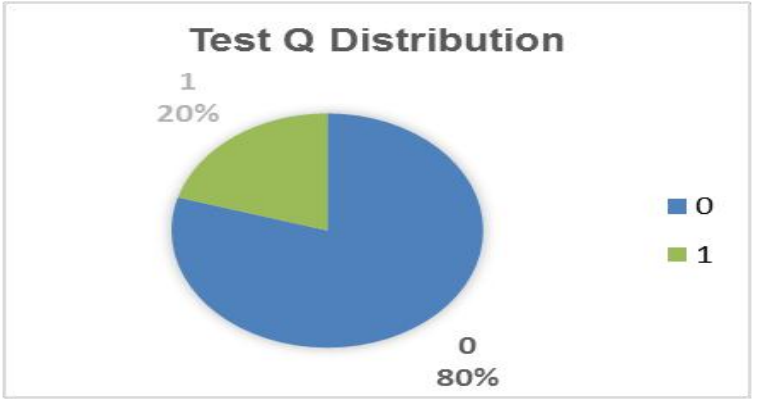
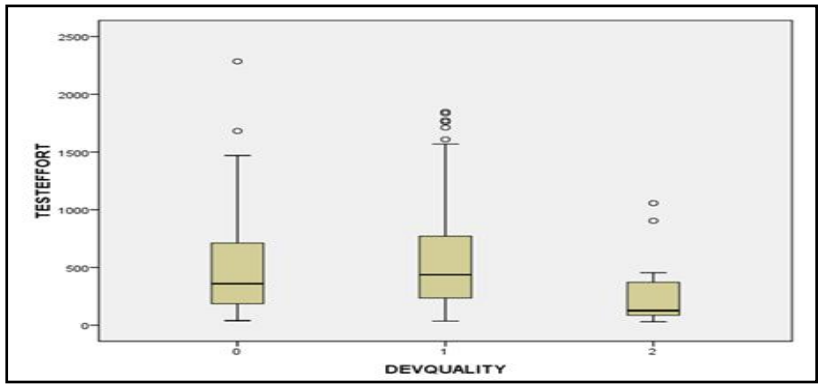
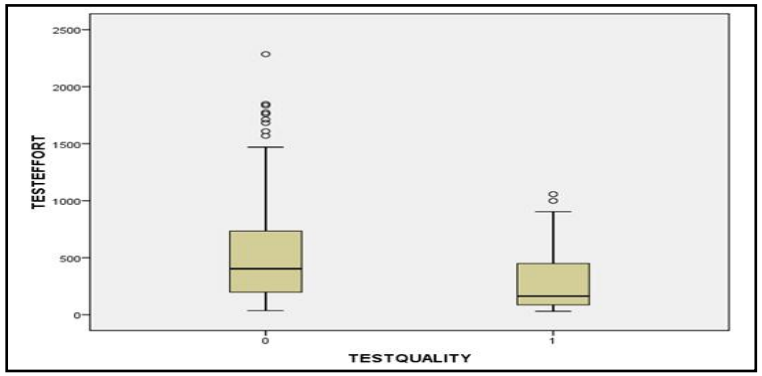
Development & Testing Process Quality in Projects









Statistical Test	Variable	P Value
Chi Square P Value	Size	< 0.001
Kruscal_Wallis Test	DevQ	0.005
Mann Whitney Test	TestQ	0.003

Data Set	Correlation coefficient
Data Set A	0.3565
Data Set A PG1	0.9035
Data Set A PG2	0.8572
Data Set A PG3	0.8752

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TEST ESTIMATION MODELS

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Data Sets for Analysis

- ✓ **Data Set A**
  - Basic data set consisting of both IFPUG 4.1 & COSMIC FP measured projects.
  - Consists of 142 data points.
- ✓ **Data Set B**
  - Architecture type, ‘blanks’ were removed from Data Set A.
  - Consists of 72 data points.
- ✓ **Data Set C**
  - Subset of Data Set A and covers COSMIC measured projects.
  - Consists of 82 data points.
- ✓ **Data Set D**
  - Subset of Data Set A covering IFPUG measured projects;
  - Consists of 60 data points.

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Test Estimation Models (Data Set A)

Model ID	PG	Independent Variables	Model Coefficients							
			A	B	D1		D2		T1	T2
					DevQ=0	DevQ=1	DevQ=0	DevQ=1	TestQ=0	TestQ=0
1	1	Size	1.617	0.604						
2	2	Size	20.69	1.705						
3	3	Size	98.13	4.801						
4	1	Size, DevQ	16.12	0.485	19.347	-39.375	-0.23	0.214		
5	2	Size, DevQ	20.57	1.56	-94.1	34.077	0.562	-0.009		
6	3	Size, DevQ	38.85	3.734	-55.913	92.609	2.14	0.852		
7	1	Size, DevQ,TestQ	-9.62	0.65	6.967	-41.78	0.003	0.193	38.124	-0.191
8	2	Size, DevQ,TestQ	30.74	1.541	-19.755	62.481	-0.039	-0.338	-84.511	0.62
9	3	Size, DevQ,TestQ	38.85	3.734	-55.913	92.609	2.14	852	0	0

Using Estimation Models 1, 2 & 3 based on Size:

Test Effort = A + B * (Size)

Using Estimation Models 4, 5 & 6 based on Size and DevQ

Test Effort = A + B * (Size) + D1 + D2 * (Size)

Using Estimation Models 7, 8 & 9 based on Size, DevQ and TestQ

Test Effort = A + B * (Size) + D1 + D2 * (Size) + T1 + T2 * (Size)

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Test Estimation Models (Data Set B, COSMIC and IFPUG)

Data Set B Models

Model ID	PG	Independent Variables	Model Coeffecients							
			A	B	D1		D2		T1	T2
					DevQ=0	DevQ=1	DevQ=0	DevQ=1	TestQ=0	TestQ=0
10	1	Size	-8.3448	0.61						
11	2	Size	-30.569	1.929						
12	3	Size	-157.62	6.126						
13	1	Size, DevQ	16.124	0.485	46.572	-52.672	-0.201	0.222		
14	2	Size, DevQ	20.57	1.56	-180.84	-60.58	0.973	0.313		
15	3	Size, DevQ	38.847	3.734	-375.38	5.027	3.881	1.449		
16	1	Size, DevQ,TestQ	-12.583	0.68	58.608	-43.272	-0.208	0.171	16.67	-0.188
17	2	Size, DevQ,TestQ	56.462	1.492	2.443	129.634	-0.354	-1.025	-219.18	1.395
18	3	Size, DevQ,TestQ	38.847	3.734	-375.38	5.027	3.881	1.449	0	0

COSMIC Data Set Models

Model ID	PG	Independent Variables	Model Coeffecients	
			A	B
19	1	Size	-20.142	0.693
20	2	Size	47.999	1.590
21	3	Size	136.267	4.481

IFPUPG Data Set Models

Model ID	PG	Independent Variables	Model Coeffecients	
			A	B
22	1	Size	37.588	0.455
23	2	Size	-29.939	1.917
24	3	Size	77.585	6.087

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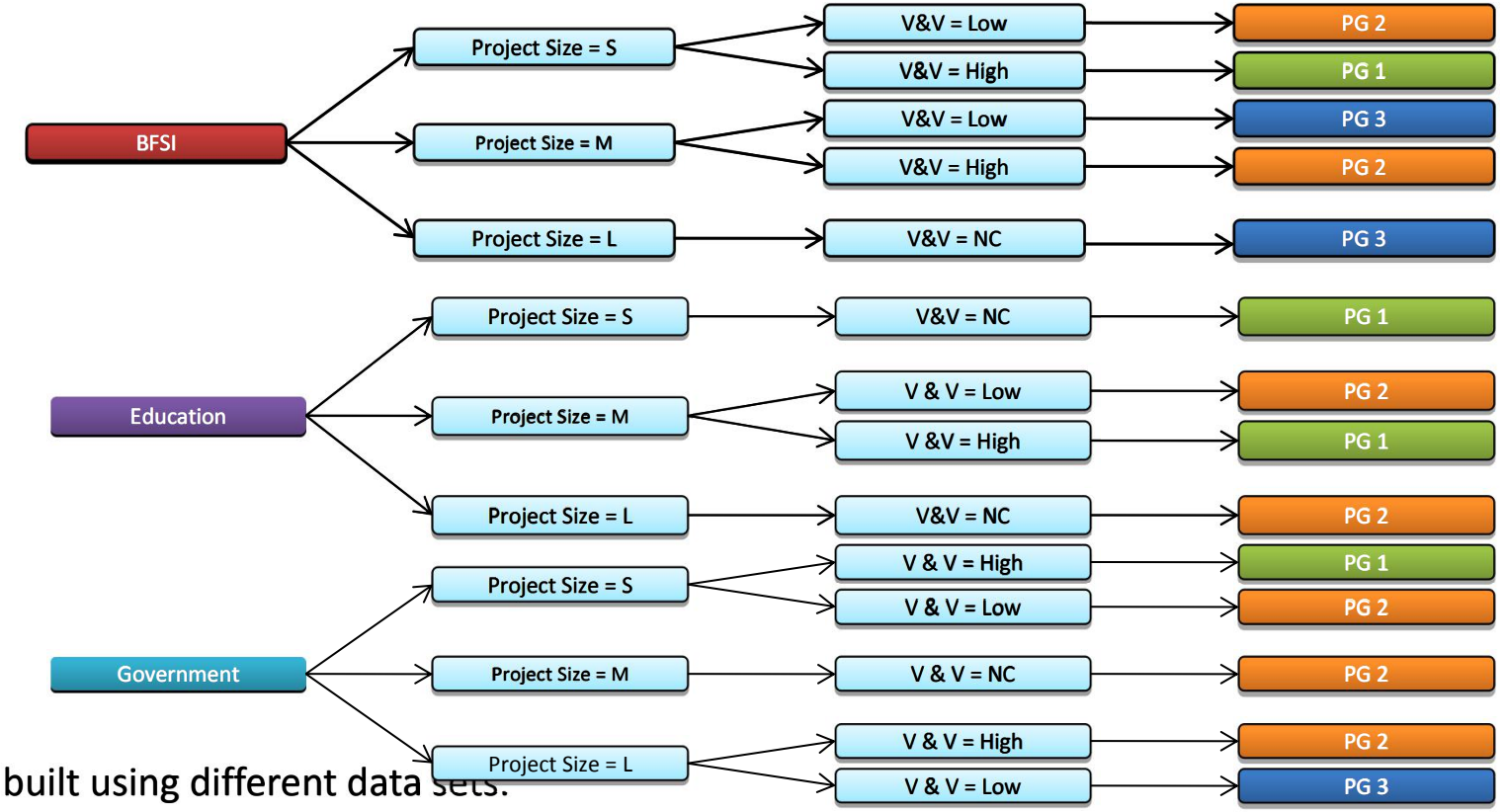
Selecting an Estimation Model

(1) Decide the Project Group

Team Size	Elapsed Time	Project Size
Small	Small	Small (S)
Small	Medium	Small (S)
Small	Large	Medium (M)
Medium	Small	Small (S)
Medium	Medium	Medium (M)
Medium	Large	Medium (M)
Large	Small	Medium (M)
Large	Medium	Large (L)
Large	Large	Large (L)



(2) Decide the relevant portfolio from models built using different data sets.

(3) Choose the model based on the availability of values for independent variables

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Evaluation of Test Estimation Models

Portfolio	Model Id	No. of Projects	R^2	Adj R^2	MedMRE	Mallow's Cp
A (N=142)	1	46	0.82	0.81	0.24	2
	2	49	0.74	0.73	0.27	2
	3	47	0.77	0.79	0.25	2
	4	46	0.85	0.83	0.24	6
	5	49	0.75	0.73	0.28	6
	6	47	0.79	0.77	0.22	6
	7	46	0.86	0.83	0.23	8
	8	49	0.78	0.74	0.24	8
	9	47	0.79	0.77	0.22	6
B (N = 72)	10	32	0.80	0.8	0.24	2
	11	24	0.67	0.66	0.26	2
	12	16	0.83	0.82	0.25	2
	13	32	0.84	0.81	0.22	6
	14	24	0.70	0.62	0.25	6
	15	16	0.91	0.86	0.10	6
	16	32	0.87	0.83	0.20	8
	17	24	0.70	0.57	0.25	8
	18	16	0.91	0.86	0.10	6
C (N = 82)	19	27	0.87	0.86	0.19	2
	20	26	0.73	0.71	0.30	2
	21	29	0.82	0.82	0.23	2
D (N = 60)	22	19	0.78	0.77	0.25	2
	23	23	0.76	0.75	0.26	2
	24	18	0.70	0.68	0.33	2

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Predictive Performance of Estimation Models

Portfolio	Model ID	PG	Variables	# of Data Points	MRE		
					Percentile 25	Percentile 50	Percentile 75
A	1	1	Size	65	0.13	0.24	0.38
	2	2	Size	76	0.13	0.27	0.38
	3	3	Size	73	0.11	0.25	0.4
	4	1	Size, DevQ	65	0.14	0.24	0.39
	5	2	Size, DevQ	76	0.13	0.28	0.4
	6	3	Size, DevQ	73	0.08	0.22	0.39
	7	1	Size, DevQ,TestQ	65	0.12	0.23	0.35
	8	2	Size, DevQ,TestQ	76	0.08	0.24	0.36
	9	3	Size, DevQ,TestQ	73	0.08	0.22	0.39
B	10	1	Size	23	0.17	0.24	0.35
	11	2	Size	26	0.18	0.26	0.37
	12	3	Size	24	0.05	0.25	0.42
	13	1	Size, DevQ	23	0.11	0.22	0.42
	14	2	Size, DevQ	26	0.17	0.25	0.38
	15	3	Size, DevQ	24	0.03	0.1	0.39
	16	1	Size, DevQ,TestQ	23	0.07	0.2	0.38
	17	2	Size, DevQ,TestQ	26	0.1	0.25	0.36
	18	3	Size, DevQ,TestQ	24	0.03	0.1	0.39
C	19	1	Size	16	0.11	0.19	0.35
	20	2	Size	16	0.2	0.3	0.45
	21	3	Size	37	0.1	0.23	0.34
D	22	1	Size	48	0.13	0.25	0.34
	23	2	Size	58	0.07	0.26	0.37
	24	3	Size	35	0.13	0.33	0.45

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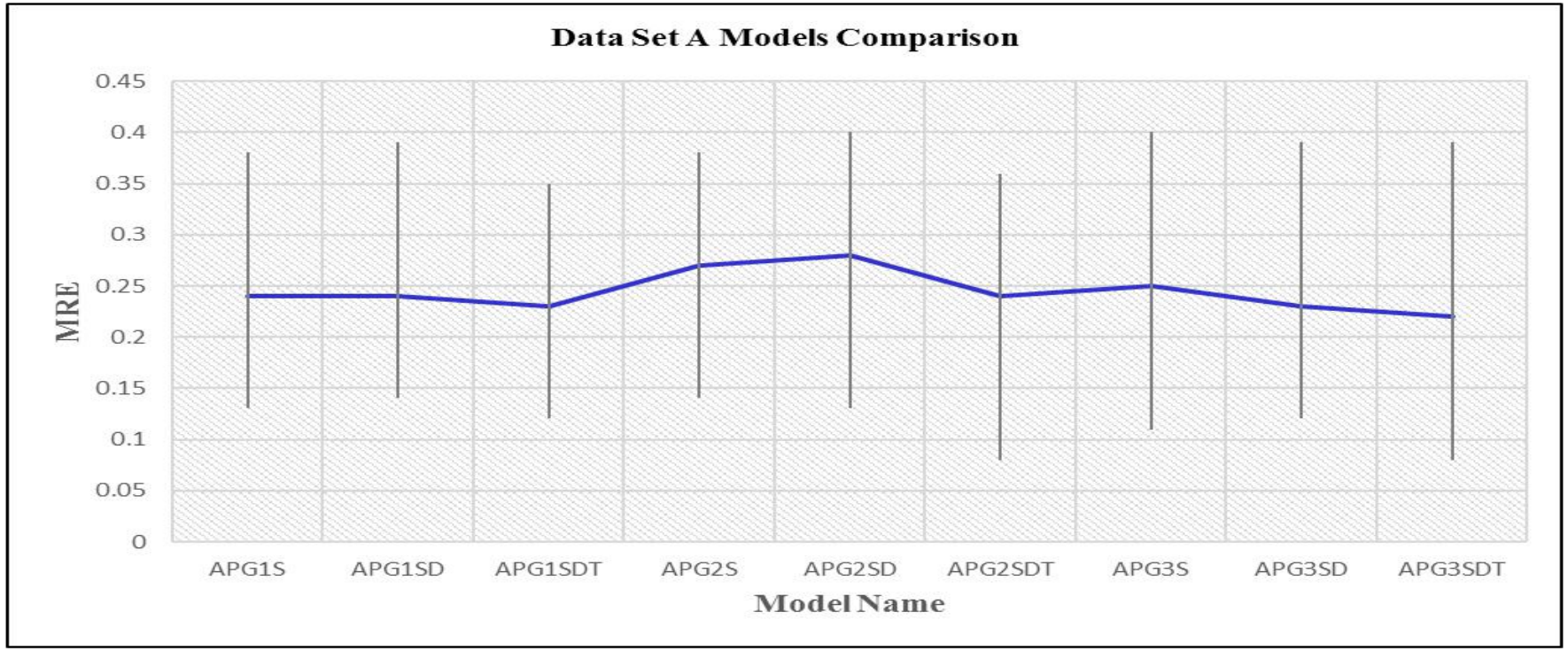
Model Comparisons within Data Set A



- **Models using both Size & DevQ are better than Size based models except for PG2.**
- **Models using Size, DevQ and TestQ is always better than Size and 'Size & DevQ'**

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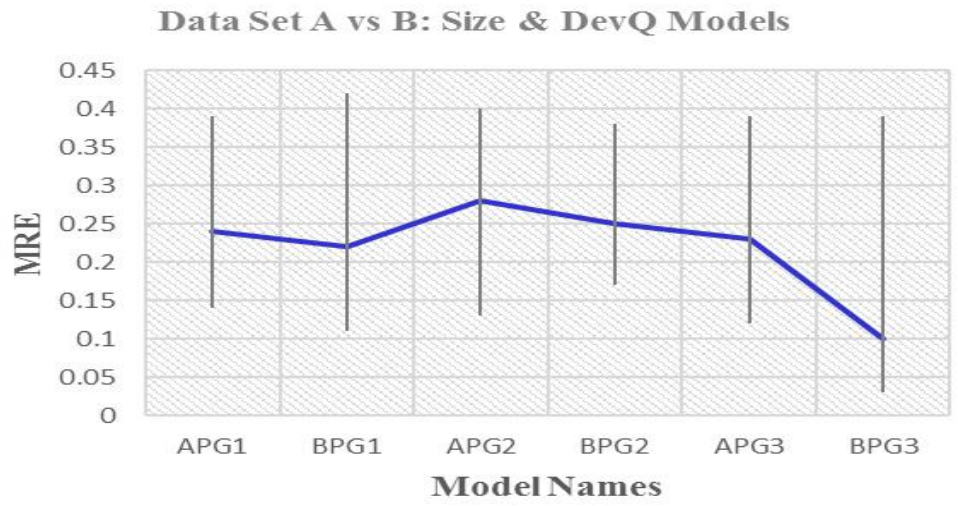
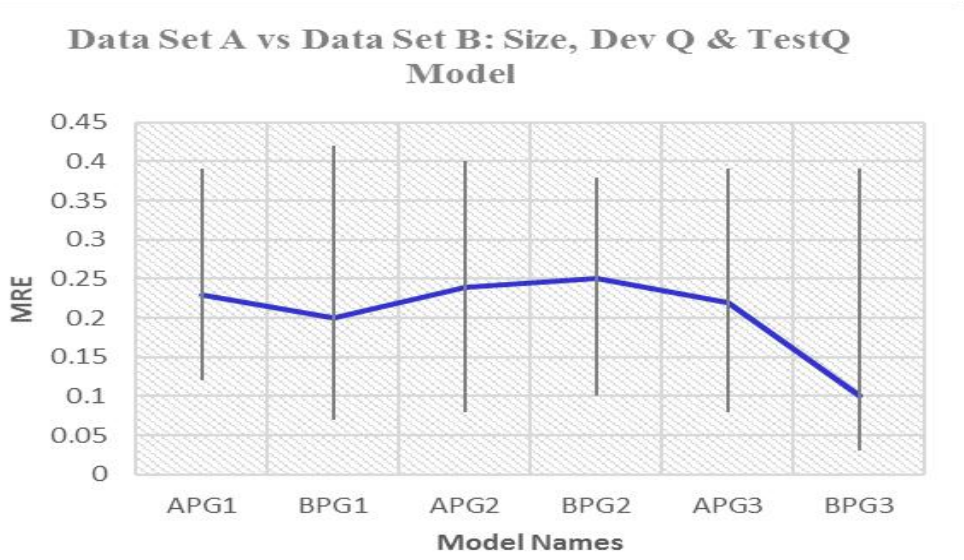
Model Comparisons between Data Sets A and B





- **Portfolio B consistently performs better than models from Portfolio A except for PG2 with Size, DevQ and TestQ.**

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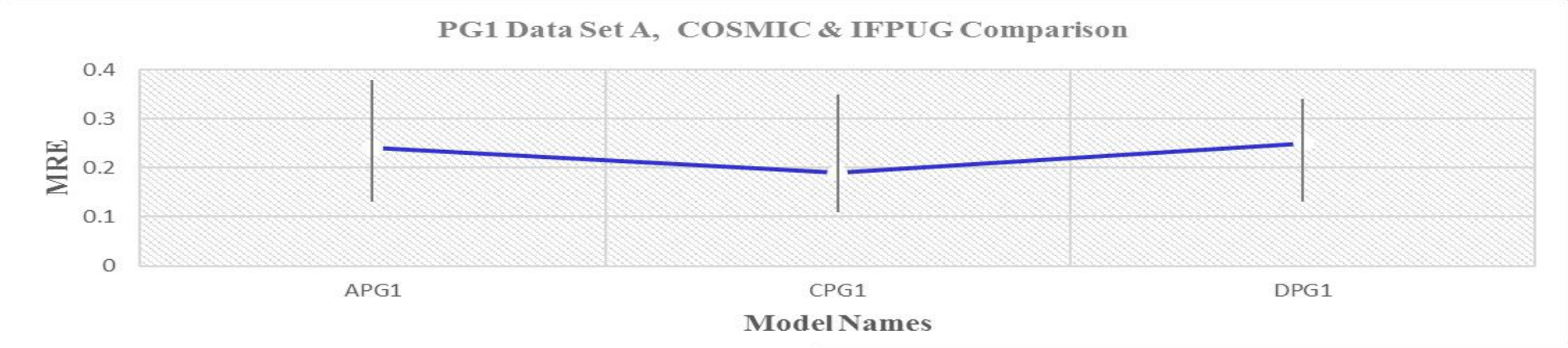
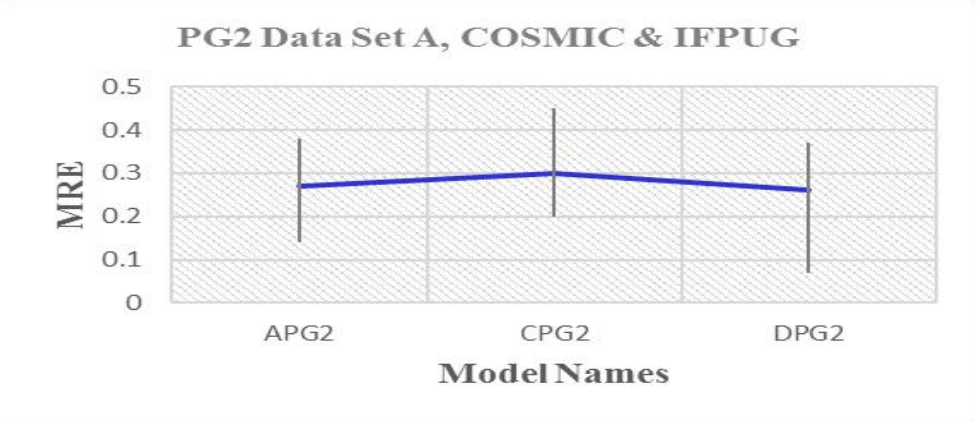
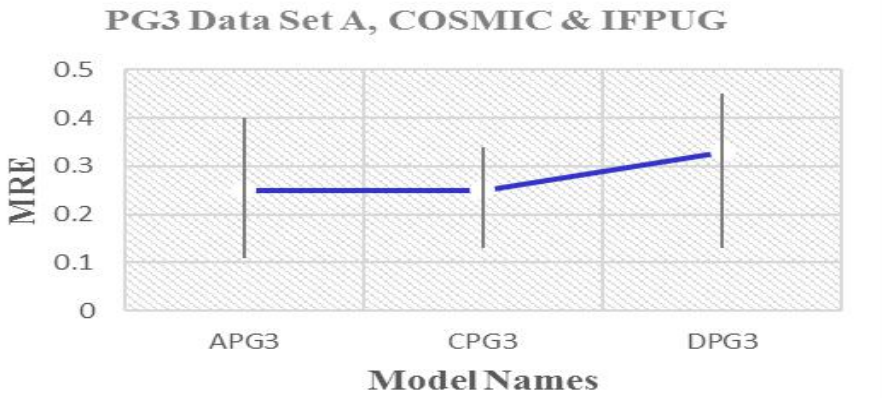
Data Set A vs COSMIC vs IFPUG Size Based Models







- **COSMIC estimation models perform better for PG1 and PG3 project groups**
- **COSMIC PG3 model demonstrates the best predictability with the lowest variation**.

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Journal of Software Engineering & Research – April 2017

Estimation Models for Software Functional Test Effort

Kamala Ramasubramani Jayakumar, Alain Abran

Journal of Software Engineering and Applications Vol.10 No.4

Pub. Date: April 27, 2017

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COSMIC in Software Testing

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Use of COSMIC in Testing

- Test Effort Estimation
- Test Case Development
- Test Case Optimization

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Survey of Test Estimation Techniques

- **Judgment & Rules of Thumb based Techniques**
  - Delphi, Rules of Thumb,
- **Analogy & Work-break Down Techniques**
  - Analogy, Task based, Bottom-Up, Top-Down, Test Case Enumeration
- **Factors & Weights based Techniques**
  - Test Point Analysis, Use Case Points, Test Execution Point, Cognitive Information Complexity Measurement Model
- **Size based Estimation Techniques**
  - Test Size based Estimation, AssessQ Model, Estimating Test Volume & Effort
- **Fuzzy & Other Approaches**
  - ANN Estimation, Fuzzy Size (COCOMO), Fuzzy Drivers (COCOMO)

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Comparison of Test Effort Estimation Techniques

Criteria Estimation Techniques	Customer view of requirements	Functional size as a pre-requisite	Mathematical validity	Verifiable	Benchmarking
1- Judgment & Rules of Thumb	NO	NO	Not applicable	NO	NO
2- Analogy & Work-breakdown	NO	NO	YES	YES	Partially, and only when standards are used
3- Factors & Weights	NO	NO	NO – units are most often ignored	YES	NO
4- Size-based	YES	YES	Varies with sizing technique selected	YES	YES
5- Fuzzy & Others	Partially	Most often, No	YES in general, but at times, units are ignored	Partially	Partially, and only when standards are used

Size based estimation performs better than other categories.

COSMIC FP Size based test effort estimation scores better than IFPUG size based estimation. (Refer earlier slide)

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Journal of Software Engineering & Research

A Survey of Software Test Estimation Techniques

Kamala Ramasubramani Jayakumar, Alain Abran

Journal of Software Engineering and Applications Vol.6 No.10A

Pub. Date: October 29, 2013

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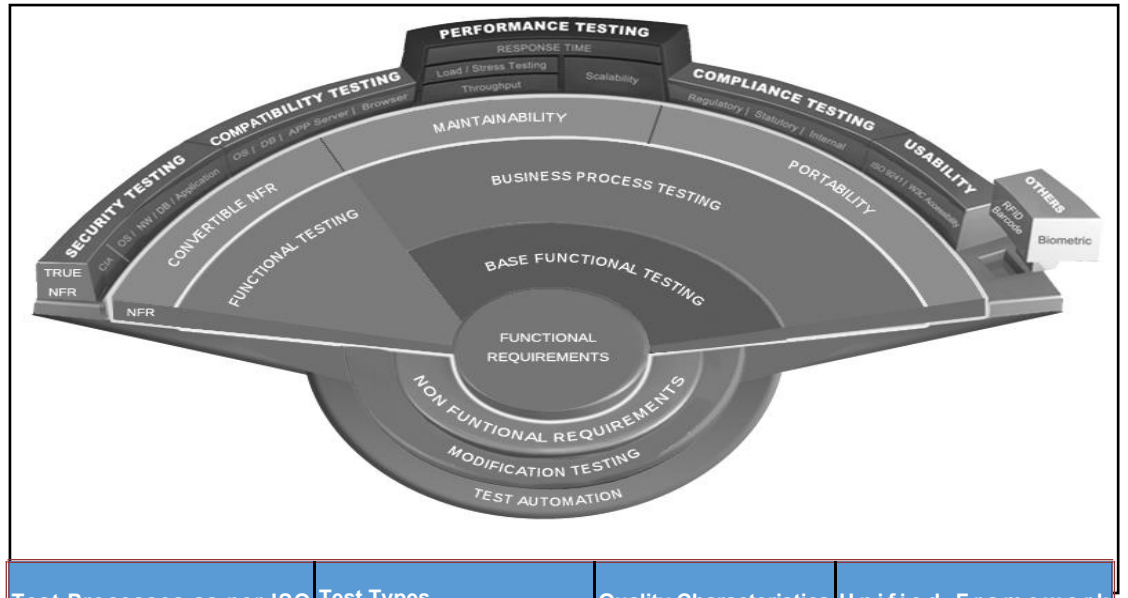
Unified Framework for Software Test Estimation

Test Type	Framework Component	Measure	Unit of Measure	Model Technique
Functional	Functional Testing	Functional Size	CFP	Regression
		Functional Test Effort	Hours	Regression
	Business Process Testing	Business Process Size	CFP	Regression
		Business Process Test Effort	Hours	Regression
Non-Functional	Convertible NFR Testing	Functional Size of Convertible NFR	CFP	Regression
		Converted NFR Test Effort	Hours	Regression
	Non Convertible NFR Testing	True NFR Test Effort	Hours	Fuzzy Inference
Modification	Modification Testing	Impact Size	CFP	Regression
		Modification Test Efforts	Hours	Regression
Test Automation	Automated Testing	Functional Test Automation Size	CFP	Regression
		Functional Test Automation Efforts	Hours	Regression



Test Processes as per ISO 29119	Test Types as per ISO 29119	Quality Characteristics as per ISO 25010	Unified Framework Components	
Dynamic Test Processes	Functional Testing	Functional Suitability	**Functional Testing**	
			Base Functional Testing	Business Process Testing
	Performance Testing Security Testing Usability Testing Compatibility Testing Reliability Testing Portability Testing Maintainability Testing	Performance Security Usability Compatibility Reliability Portability Maintainability	**Non Functional Testing**	
			Convertible NFR	True NFR

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Map to COSMIC Model and Create Test Cases

- Script Test cases for validations of Entry Data group (based on type, length etc.,)
- Script Test cases for producing all eXit data movements for each entry test data.
- Script Test cases for availability/ non availability of data read in Read Data Movements for each entry test data.
- Script Test cases that would write data for all write data movements for each entry test data.

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Test Case Optimization – Equivalence classes

- Scenario based black box testing in COSMIC – by Abu Talib, Olga Ormandjeva, Alain Abran, Software Quality Professional, 2016
- COSMIC Model used for building test scenario based on test cases.
- Test cases are portioned into equivalent classes based on similarity and dissimilarity.
- Measure of Functional complexity is used for prioritization of test cases
- Best possible coverage with optimal use of resources.

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CONCLUSIONS

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Conclusions

1. Discovery of test productivity patterns & related project characteristics.
2. Process variables DevQ & TestQ and their impact on test effort estimation.
3. Comprehensive Unified Framework for Software Test Estimation.
4. COSMIC - a better method for size measurement resulting in more accurate test effort estimates.

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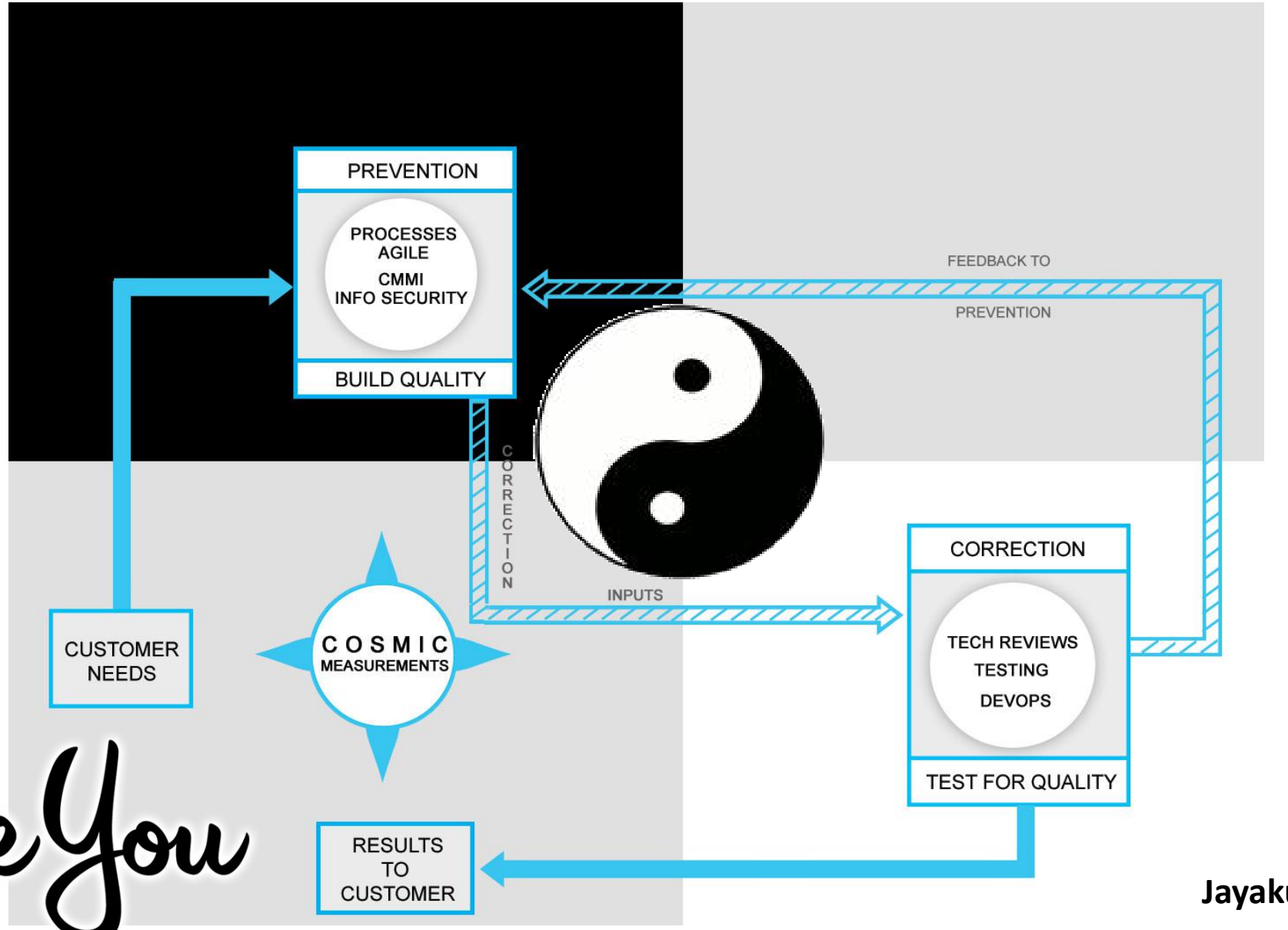

Thank You

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