REFERENCES

1. Wang, Y., et al., *Integrate The GM(1,1) and Verhulst Models to Predict Software Stage Effort.* IEEE Trans. Syst. Man. Cy. C, 2009. **39**(6): p. 647-658.
2. Zia, Z., A. Rashid, and K. uz Zaman, *Software Cost Estimation for Componentbased Fourth-Generation-Language Software Applications.* Software, IET, 2011. **5**(1): p. 103-110.
3. Azzeh, M., P.I. Cowling, and D. Neagu. *Software Stage-Effort Estimation Based on Association Rule Mining and Fuzzy Set Theory*. in *Proc. 2010 IEEE 10th International Conference on Computer and Information Technology (CIT)*. 2010.
4. Boehm, B.W., *Software Engineering Economics*. 1981, Upper Saddle River, NJ: Prentice Hall PTR.
5. Menzies T. , C.B., Kocaguneli E., Krall J., Peters F., and TurhanB., *The PROMISE Repository of empirical software engineering data*. 2012.
6. Boehm, B.W., et al., *Software Cost Estimation with COCOMO II*. 2000, Upper Saddle River, NJ: Prentice Hall PTR.
7. Gencel, C. and O. Demirors, *Functional Size Measurement Revisited.* ACM Trans. Softw. Eng. Methodol., 2008. **17**(3): p. 15:1-15:36.
8. Tan, H.B.K., Y. Zhao, and H. Zhang, *Conceptual Data Model-Based Software Size Estimation for Information Systems.* ACM Trans. Softw. Eng. Methodol., 2009. **19**(2): p. 4:1-4:37.
9. Muzaffar, Z. and M.A. Ahmed, *Software Development Effort Prediction: A Study on The Factors Impacting The Accuracy of Fuzzy Logic Systems.* Inf. Softw. Technol., 2010. **52**(1): p. 92-109.
10. Malik, A.A. and B.W. Boehm, *Quantifying Requirements Elaboration to Improve Early Software Cost Estimation.* Inf. Sci., 2011. **181**(13): p. 2747-2760.
11. Symons, A.L., *Function Point Analysis: Difficulties and Improvements.* IEEE Trans. Software Eng., 1988. **14**(1): p. 2-11.
12. Karner, G., *Resource Estimation for Objectory Projects.* {O}bjective {S}ystems {SF} {AB}, 1993.
13. Park, R.E., *Software Size Measurement: A Framework for Counting Source Statements*. 1992, Software Engineering Institute, Carnegie Mellon University: Pittsburgh, PA.
14. Abran, A. and P.N. Robillard, *Function Points Analysis: An Empirical Study of Its Measurement Processes.* IEEE Trans. Software Eng., 1996. **22**(12): p. 895-910.

15. Albrecht, A.J. *Measuring Application Development Productivity*. in *IBM Application Development Symp.* 1979.

16. Albrecht, A.J. and J.E.J. Gaffney, *Software Function, Source Lines of Code, and Development Effort Prediction: A Software Science Validation.* IEEE Trans. Software Eng., 1983. **SE-9**(6): p. 639-648.

17. Albrecht, A.J., *AD/M Productivity Measurement and Estimate Validation-Draft*. 1984: IBM Corp.

18. IBMCIS--A Guideline313, *AD/M Productivity Measurement and Estimate Validation*. 1984.

19. *Function Point Counting Practices Manual -- Release 4.3.1*. 2010.

20. *The COSMIC Functional Size Measurement Method v.3.0.1, Measurement Manual*. 2008.

21. *MK II Function Point analysis Counting Practices Manual -- version 1.3.1*. 1998.

22. Diev and Sergey, *Use Cases Modeling and Software Estimation: Applying Use Case Points.* SIGSOFT Softw. Eng. Notes, 2006. **31**(6): p. 1-4.

23. Banker, R.D., R.J. Kauffman, and R. Kumar, *An Empirical Test of Object-Based Output Measurement Metrics in A Computer Aided Software Engineering (CASE) Environment.* J. Manage. Inf. Syst., 1991. **8**(3): p. 127-150.

24. Haykin, S., *Neural Networks and Learning Machines*. 2008, Upper Saddle River, NJ: Prentice Hall.

25. Jang, J.-S.R., *ANFIS: Adaptive-Network-Based Fuzzy Inference System.* IEEE Transactions on Systems, Man and Cybernetics, 1993. **23**(3): p. 665-685.

26. Yang, Y., et al. *Phase Distribution of Software Development Effort*. in *Proc. the Second ACM-IEEE International Symposium on Empirical Software Engineering and Measurement*. 2008. New York, NY, USA: ACM.

27. Kultur, Y., E. Kocaguneli, and A.B. Bener. *Domain Specific Phase by Phase Effort Estimation in Software Projects*. in *Proc. 24th International Symposium on Computer and Information Sciences (ISCIS 2009)*. 2009.

28. Putnam, L.H., *A General Empirical Solution to the Macro Software Sizing and Estimating Problem.* IEEE Trans. Software Eng., 1978. **SE-4**(4): p. 345-361.

29. Boehm, B.W., *Software Engineering Economics.* IEEE Trans. Software Eng., 1984. **SE-10**(1): p. 4-21.

30. Boehm, B.W., et al. *Cost Models for Future Software Life Cycle Processes: COCOMO 2.0.* in *Annals of Software Engineering*. 1995.

31. Clark, B.K., S. Chulani, and B.W. Boehm. *Calibrating The COCOMO II Post-Architecture Model*. in *Proc. The 1998 International Conference on Software Engineering*. 1998.

32. Oliveira, A.L.I., *Estimation of Software Project Effort with Support Vector Regression.* Neurocomputing, 2006. **69**(13-15): p. 1749-1753.

33. Chiu, N.H. and S.J. Huang, *The Adjusted Analogy-Based Software Effort Estimation Based on Similarity Distances.* J. Syst. Softw., 2007. 80(4): p. 628-640.

34. Huang, S.J., N.H. Chiu, and Y.J. Liu, *A Comparative Evaluation on The Accuracies of Software Effort Estimates from Clustered Data.* Inf. Softw. Technol., 2008. **50**(9-10): p. 879-888.

35. de Barcelos Tronto, I.F., J.D.S. da Silva, and N. Sant'Anna, *An Investigation of Artificial Neural Networks Based Prediction Systems in Software Project Management.* J. Syst. Softw., 2008. **81**(3): p. 356-367.

36. Keung, J.W., B.A. Kitchenham, and D.R. Jeffery, *Analogy-X: Providing Statistical Inference to Analogy-Based Software Cost Estimation.* IEEE Trans. Software Eng., 2008. **34**(4): p. 471-484.

37. Kumar, K.V., et al., *Software Development Cost Estimation Using Wavelet Neural Networks.* J. Syst. Softw., 2008. **81**(11): p. 1853-1867.

38. Liu, Q., et al., *Evaluation of Preliminary Data Analysis Framework in Software Cost Estimation Based on ISBSG R9 Data.* Softw. Qual. J., 2008. **16**: p. 411-458.

39. Huang, S.J. and N.H. Chiu, *Applying Fuzzy Neural Network to Estimate Software Development Effort.* Appl. Intell., 2009. **30**: p. 73-83.

40. Elish, M.O., *Improved Estimation of Software Project Effort Using Multiple Additive Regression Trees.* Expert Syst. Appl., 2009. **36**(7): p. 10774-10778.

41. Mittal, A., K. Parkash, and H. Mittal, *Software Cost Estimation Using Fuzzy Logic.* SIGSOFT Softw. Eng. Notes, 2010. **35**(1): p. 1-7.

42. Kocaguneli, E., et al., *Exploiting The Essential Assumptions of Analogy-Based Effort Estimation.* IEEE Trans. Software Eng., 2012. **38**(2): p. 425-438.

43. Kocaguneli, E., T. Menzies, and J.W. Keung, *On the Value of Ensemble Effort Estimation.* IEEE Trans. Software Eng., 2012. **38**(6): p. 1403-1416.

44. Dejaeger, K., et al., *Data Mining Techniques for Software Effort Estimation: A Comparative Study.* IEEE Trans. Software Eng., 2012. **38**(2): p. 375-397.

45. MacDonell, S.G. and M.J. Shepperd. *Using Prior-Phase Effort Records for Re-Estimation during Software Projects*. in *Proc. the Ninth International Software Metrics Symposium (METRICS'03)*. 2003.

46. Abrahamsson, P., et al. *Effort Prediction in Iterative Software Development Processes -- Incremental Versus Global Prediction Models*. in *Proc. 2007 First International Symposium on Empirical Software Engineering and Measurement (ESEM)*. 2007.

47. Wang, Y., Q. Song, and J. Shen. *Grey Learning Based Software Stage-Effort Estimation*. in *Proc. 2007 International Conference on Machine Learning and Cybernetics*. 2007.

48. Jarque, C.M., *International Encyclopedia of Statistical Science, Jarque-Bera Test Part*. 2011: Springer-Verlag Berlin Heidelberg.

49. Conte, S.D., H.E. Dunsmore, and V.Y. Shen, *Software Engineering Metrics and Models*. 1981, Menlo Park, CA: Benjamin-Cummings.

50. Junling, R. *A Pattern Selection Algorithm Based on The Generalized Confidence*. in *Proc. 18th International Conference on Pattern Recognition (ICPR '06*. 2006.

51. Kankainen, A., S. Taskinen, and H. Oja, *On Mardia's Tests of Multinormality*. Statistics for Industry and Technology, 2004: p. 153-164.

52. Kitchenham, B.A., et al., *What Accuracy Statistics Really Measure [Software Estimation]*. Proc. IEE-Software, 2001. **148**(3): p. 81-85.

53. Wong, J., D. Ho, and L.F. Capretz. *An Investigation of Using Neuro-Fuzzy with Software Size Estimation*. in *Proc. ICSE Workshop on Software Quality. (WOSQ '09)*. 2009.

54. Miyazaki, Y., et al., *Method to Estimate Parameter Values in Software Prediction Models*. Inf. Softw. Technol., 1991. **33**(3): p. 239-243.

55. Foss, T., et al., *A Simulation Study of The Model Evaluation Criterion MMRE*. IEEE Trans. Software Eng., 2003. **29**(11): p. 985-995.

56. Gibbons, J.D. and S. Chakraborti, *Nonparametric Statistical Inference*. 2003, Madison Avenue, NY: Marcel Dekker.

57. Refaeilzadeh P., T.L., and Liu L., *Encyclopedia of Database Systems—Cross Validation*. 2009: Springer New York.

58. Sarle, W.S. *How many hidden units should I use?* . [cited 2014; Available from: http://www.faqs.org/faqs/ai-faq/neural-nets/part3/section-10.html.

59. V. Nguyen, S.D.-R., T. Tan, and B. Boehm., *A SLOC Counting Standard*. 2007.

APPENDIX

The data are questionnaire feedback from two local software development companies. In thirty eight software projects, the first thirty three projects are taken from a government and remaining projects are from a company organization. Appendix A is an example of questionnaires. Appendix B provides general data of software projects. Appendix C yields details of features and software project data used as inputs for creating estimation models while Appendix D yields software efforts used as outputs for establishing estimation models.

APPENDIX A

This section provides an example of questionnaire for collecting software project data as shown in below.

QUESTIONNAIRE FOR COLLECTING SOFTWARE PROJECT DATA

Section 1: General Data

1.1 Project name: .....
1.2 Description.....
.....
.....
1.3 Maximum team size.....
1.4 Programming language.....
1.5 Development type.....
1.6 Application domain.....
1.7 Software process model.....
1.8 Intended market.....

Section 2: Features of Software Projects.

All of 44 following features are inspirited by four data collection formats. i.e., twenty three, twelve, four, and five features being derived from COCOMO II model, IFPUG FSM, Mk II FPA, UCP, respectively.

2.1 Feature derived from COCOMO II (23 Features) [6]

1. Source lines of code (KSLOC).....
   (Please use Unified Code Count tool [59] to count the SLOC to comply with COCOMO II SLOC check list [6].)
2. Development Flexibility (FLEX): Is there any flexibility with respect to the requirements? .....

	Extra Low	Extra Low	Extra Low	Extra Low	Extra Low	Extra High
FLEX	rigorous	occasional relaxation	some relaxation	general conformity	some conformity	general goals

3. Execution Time Constraint (TIME): How many use of available execution time? .....

	Extra Low	Extra Low	Extra Low	Extra Low	Extra Low	Extra High
TIME			50% use of available execution time	70%	85%	95%

*** In [6] provides descriptions of remaining features (STOR DOCU, RELY, CPLX, RUSE, DATA, PVOL, TEAM, PCON, ACAP, PCAP, PREC, APEX, PLEX, LTEX, RESL, PMAT, TOOL, SITE, and SCED)

2.2 Features from IFPUG FSM (12 features) [19]

1. Performance (PERF): Is there peak time of transactions? .....

Extra Low	There is no special performance requirement required.
Very Low	There is performance design required.
Low	There is critical response time for peak hours.
Nominal	There is critical response time during all business hours.
High	Additionally, performance analysis tasks are required in the design phase.
Very High	Additionally, performance analysis tools are required in the design, coding, and transition phases.

2. Transaction Rate (TRAN): How much the rate of business transactions influenced the development of the application? .....

Extra Low	There is no peak transaction.
Very Low	There are low transaction rates minimally effecting on the design, development, and installation phases.
Low	There are average transaction rates some affecting the design, development, and installation phases.
Nominal	There are high transaction rates affecting the design, development, and installation phases.

High	There are performance analysis tasks applied in the design, development, and installation phases.
Very High	Additionally, there are performance analysis tools required.

*** In [19] provides descriptions of remaining features (CONF, DIST, COMM, ENTR, UPDA, DESI, CHAN, INST, OPER, and ISIT)

2.3 Feature from Mk II FPA (4 features) [21]

1. Requirements of Other Applications (APPL): How many applications are connected? .....

Extra Low	An application is totally stand-alone
Very Low – Very High	An application needs interfacing or sharing data with other applications. Let VL to VH for 1 to 5 applications.

2. Security (SECU): How is security setting? ..... (Add the relevant score below)

Count 1	Count 1	Count 2	Count 1
An application needs personal, legal, and privacy.	An application needs special audit.	An application needs exceptional security.	An application needs encryption of data communications.

	Extra Low	Very Low	Low	Nominal	High	Very High
SEU	0	1	2	3	4	5

3. User Training Needs (TRAI): Is there user manual (help, document, or online)? .....

Extra Low	There is no special training materials or courses required
Very Low	There is a tutorial help required.
Low	There is a HTML tutorial required.
Nominal	There is a training course material required.
High	There is an on-Line training course material required.
Very High	There is a simulator for training required.

4. Direct Use by Third Parties (PART): Are applications connected to read, update, create, or delete the data? .....

Extra Low	No third party connection to the application
Very Low	An application does not send to or receive from known third parties.
Low	An application directly connects to known third parties in read-only mode.
Nominal	An application directly connects to known third parties with on-line update capability.
High	An application directly connects to known third parties with on-line create, update, and delete capability.
Very High	An application can be accessed by unknown third parties.

2.4 Feature from UCP (5 features) [12]

1. Familiarity with Software process (SWPR): How familiarity of software process is to staffs? .....

	Extra Low	Very Low	Low	Nominal	High	Very High
SWPR	-	2 months	6 months	1 year	3 years	6 years

2. Part time workers (WORK): Are there part-time staffs in a project? .....

	Extra Low	Very Low	Low	Nominal	High	Very High
WORK	0 persons	1 persons	2 persons	3 persons	5 persons	8 persons

3. Motivation (MOTI): How large is the motivation of project team to work a project?....

	Extra Low	Very Low	Low	Nominal	High	Very High
MOTI	Extra Low	Very Low	Low	Nominal	High	Very High

4. Difficult Programming language (LANG): How difficult is the programing language? ..

	Extra Low	Very Low	Low	Nominal	High	Very High
LANG	-	5 GL	4 GL	3 GL	2 GL	1 GL

5. Stable requirements (REQU): User is clear what he wants? .....

	Extra Low	Very Low	Low	Nominal	High	Very High
REQU	Very Low	Low	Nominal	High	Very High	Extra High

APPENDIX B

This section provides general data of software projects, i.e., programming language, application type, application domain, development type, software process model, intended market, and maximum team size.

ID	Language	Application Type	Application Domain	Development Type	Process Model	Intended Market	Team Size
1	C#	Web application	Government	New	Waterfall	External	5
2	C#	Web application	Government	New	Waterfall	External	5

3	C#	Web application	Government	New	Waterfall	External	5
4	C#	Web application	Government	New	Waterfall	External	3
5	C#	Web application	Government	New	Waterfall	External	3
6	C#	Web application	Government	New	Waterfall	External	3
7	C#	Website	Government	New	Waterfall	Internal	8
8	C#	Web application	Government	New	Waterfall	Public	7
9	C#	Web application	Government	New	Waterfall	Public	6
10	C#	Web application	Government	New	Waterfall	Public	4
11	Visual Basic	Web API	Government	New	Waterfall	Public	11
12	PHP	Web application	Government	New	Waterfall	Public	6
13	PHP	Web application	Government	Custom	Waterfall	Public	7
14	PHP	Web application	Government	New	Waterfall	Public	5
15	C#	Web application	Government	New	Waterfall	Public	8
16	Java	Web application	Government	New	Waterfall	Public	4
17	Java	Web application	Government	New	Waterfall	Public	8
18	C#	Web application	Government	New	Waterfall	Public	6
19	C#	Web application	Government	New	Waterfall	Internal	8
20	PHP	Web application	Government	New	Waterfall	Public	8
21	C#	Web application	Government	New	Waterfall	External	7
22	C#	Web application	Government	New	Waterfall	Public	4
23	Java	Web API	Government	New	Waterfall	Public	5
24	C#	Web application	Government	New	Waterfall	Public	11
25	C#	Web API	Government	New	Waterfall	Public	15
26	Java	Web API	Government	New	Waterfall	Public	5
27	Java Android	Mobile application	Government	Re-dev	Waterfall	Internal	4
28	Java	Web API	Government	New	Waterfall	Public	4
29	C#	Web application	Government	New	Waterfall	External	15

30	C#	Web API	Government	New	Waterfall	Public	9
31	Objective C	Mobile application	Government	Re-dev	Waterfall	Internal	7
32	C#	Web application	Government	New	Waterfall	Internal	5
33	Objective C	Mobile application	Government	New	Waterfall	Public	5
34	PHP	Web application	Business	New	V-model	External	9
35	PHP	Web application	Business	New	V-model	External	10
36	PHP	Web application	Business	New	V-model	External	11
37	PHP	Web application	Business	New	V-model	External	9
38	PHP	Web application	Business	Enhance	V-model	External	10

APPENDIX C

This section provides details of features and software project data as shown in the Tables below, respectively. There are 44 features from four data collection formats, i.e., twenty three, twelve, four, and five features being derived from COCOMO II, IFPUG FSM, Mk II FPA, UCP, respectively.

No.	Feature	Description	Data format	No.	Feature	Description	Data format
1	KSLOC	Thousands of source Lines of Code	COCOMO II	23	SCED	Required Development Schedule	COCOMO II
2	PREC	Precedentedness	COCOMO II	24	COMM	Data Communication	IFPUG FSM
3	FLEX	Development Flexibility	COCOMO II	25	DIST	Distributed Function	IFPUG FSM
4	RESL	Architecture/Risk Resolution	COCOMO II	26	PREF	Performance	IFPUG FSM
5	TEAM	Team Cohesion	COCOMO II	27	CONF	Heavily Used Configuration	IFPUG FSM
6	PMAT	Process Maturity	COCOMO II	28	TRAN	Transaction Rates	IFPUG FSM
7	RELY	Required Software Reliability	COCOMO II	29	DESI	Design for End-Use Efficiency	IFPUG FSM
8	DATA	Database Size	COCOMO II	30	ENTR	On-Line Data Entry	IFPUG FSM
9	CPLX	Product Complexity	COCOMO II	31	UPDA	On-Line Update	IFPUG FSM
10	RUSE	Required Reusability	COCOMO II	32	INST	Installation Ease	IFPUG FSM
11	DOCU	Documentation Match to Lifecycle Needs	COCOMO II	33	OPER	Operations Ease	IFPUG FSM

12	TIME	Execution Time Constraint	COCOMO II	34	ISIT	Multiple Installation Sites	IFPUG FSM
13	STOR	Main Storage Constraint	COCOMO II	35	CHAN	Facilitate Changes	IFPUG FSM
14	PVOL	Platform Volatility	COCOMO II	36	APPL	Requirements of Other Applications	Mk II FPA
15	ACAP	Analyst Capability	COCOMO II	37	SECU	Security, Privacy, Auditability	Mk II FPA
16	PCAP	Programmer Capability	COCOMO II	38	TRAI	User Training Needs	Mk II FPA
17	PCON	Personnel Continuity	COCOMO II	39	PART	Direct use by Third Parties	Mk II FPA
18	APEX	Application Experience	COCOMO II	40	SWPR	Familiarity with software process	UCP
19	PLEX	Platform Experience	COCOMO II	41	WORK	Part time workers	UCP
20	LTEX	Language and Tool Experience	COCOMO II	42	MOTI	Motivation	UCP
21	TOOL	Use of Software Tools	COCOMO II	43	LANG	Difficult programming language	UCP
22	SITE	Multisite Development	COCOMO II	44	REQU	Stable requirements	UCP

ID	COCOMO II																							IFPUG FSM												Mk II FPA				UCP					
	KSLOC	PREC	FLEX	RESL	TEAM	PMAT	RELY	DATA	CPLX	RUSE	DOCU	TIME	STOR	PVOL	ACAP	PCAP	PCON	APEX	PLEX	LTEX	TOOL	SITE	SCED	COMM	DIST	PREF	CONF	TRAN	DESI	ENTR	UPDA	INST	OPER	IST	CHAN	APPL	SECU	TRAI	PART	SWPR	WORK	MOTI	LANG	REQU
1	45.14	H	N	L	VH	N	N	L	L	N	L	N	N	L	H	H	VH	H	N	N	N	XH	N	H	H	L	VL	L	N	VH	H	L	L	XL	VL	N	VL	N	H	H	XL	N	N	N
2	42.81	N	N	L	VH	N	N	L	L	N	L	N	N	L	H	H	VH	N	L	L	N	XH	N	H	H	L	XL	L	N	VH	H	L	L	XL	L	VL	VL	N	VL	N	XL	N	N	N
3	11.53	H	N	L	VH	N	N	L	L	N	L	N	N	L	H	H	VH	H	N	N	N	XH	N	H	H	L	XL	L	N	VH	H	L	L	XL	L	XL	VL	N	XL	H	XL	N	N	N
4	12.32	L	VH	N	VH	N	N	L	N	L	N	N	N	L	H	N	VH	H	N	N	N	XH	N	H	H	L	VL	L	N	VH	H	L	L	XL	VL	VL	VL	N	XL	H	XL	N	N	H
5	38.85	L	VH	N	VH	N	N	L	N	L	N	N	N	L	H	N	VH	VH	VH	VH	N	XH	N	H	H	L	XL	L	N	VH	H	L	L	XL	L	XL	VL	N	XL	VH	XL	N	N	H
6	26.22	L	VH	N	VH	N	N	L	N	L	N	N	N	L	H	N	VH	VH	H	H	N	XH	N	H	H	L	XL	L	N	VH	H	L	L	XL	L	XL	VL	N	XL	VH	XL	N	N	H
7	17.52	N	VH	L	VH	N	N	L	N	N	L	N	N	L	H	H	VH	H	H	H	N	XH	N	H	H	L	XL	L	N	VH	H	VL	L	XL	VL	XL	H	XL	XL	H	XL	N	L	H
8	79.82	L	VH	L	VH	N	N	L	N	N	L	N	N	L	H	H	VH	N	H	H	N	XH	N	H	H	L	XL	L	H	VH	H	VL	L	XL	VL	XL	VL	N	XL	H	XL	N	N	H
9	22.2	L	VH	L	VH	N	N	L	N	N	L	N	N	L	H	H	VH	N	H	H	N	XH	N	H	H	L	XL	L	N	VH	H	H	L	XL	VL	XL	VL	XL	XL	H	XL	N	N	H
10	8.41	L	VH	L	VH	N	N	L	N	N	L	N	N	L	H	H	VH	N	H	H	N	XH	N	H	H	L	XL	L	N	VH	H	VL	L	XL	VL	XL	VL	XL	XL	H	XL	N	N	VH
11	4.28	L	VH	L	N	N	N	L	H	XH	L	N	N	L	H	H	VH	L	N	N	N	XH	N	H	H	L	VL	L	L	VH	H	VL	L	XL	VL	VH	VL	L	VH	H	XL	N	N	H
12	5.11	H	VH	L	VH	N	N	L	N	N	L	N	N	L	H	H	VH	H	H	H	N	XH	N	H	H	L	XL	L	N	VH	H	VL	L	XL	VL	XL	N	XL	XL	H	XL	N	N	H
13	7.7	L	VH	L	XH	N	N	L	N	N	L	N	N	L	H	H	VH	L	N	H	N	XH	N	H	H	L	XL	L	N	VH	H	VL	L	XL	VL	XL	L	XL	XL	H	XL	N	N	VH
14	42.9	H	VH	L	H	N	N	L	N	N	L	N	N	L	H	H	VH	H	H	H	N	XH	N	H	H	L	XL	L	N	VH	H	VL	L	XL	VL	XL	N	XL	XL	H	XL	N	N	VH
15	4.48	L	VH	L	VH	N	H	L	N	N	L	N	N	L	H	H	VH	L	H	H	N	XH	N	H	H	L	XL	L	N	VH	H	VL	L	XL	VL	XL	N	N	XL	H	L	N	N	H
16	25.84	L	VH	L	VH	N	H	L	N	N	L	N	N	L	H	H	VH	L	H	H	N	XH	N	H	H	L	VL	L	N	VH	H	VL	L	XL	VL	L	VL	N	L	H	XL	N	N	L
17	36.27	L	VH	L	VH	N	N	L	N	XH	L	N	N	L	H	H	VH	L	H	H	N	XH	N	H	H	L	VL	L	N	VH	H	VL	L	XL	VL	VH	L	N	H	H	XL	N	N	H
18	20.94	L	VH	L	VH	N	N	L	N	N	L	N	N	L	H	H	VH	N	H	H	N	XH	N	H	H	L	XL	L	N	VH	H	VL	L	XL	VL	XL	VL	L	XL	H	XL	N	N	L
19	67.32	VH	VH	L	XH	N	N	L	N	N	L	N	N	L	H	H	VH	VH	VH	VH	N	XH	N	H	H	L	XL	L	N	VH	H	VL	L	XL	VL	XL	VL	XL	XL	VH	XL	N	N	H

ID	COCOMO II																							EPMG ESM												Mk II FPA				UCP				
	KSLOC	PREC	FLEX	RESL	TEAM	PMAT	RELY	DATA	CPLX	RUSE	DOCU	TIME	STOR	PVOL	ACAP	PCAP	PCON	APEX	PLEX	LTEX	TOOL	SITE	SCED	DOMK	DISC	PREF	CONF	TRAN	DESI	ENTH	UPDA	INST	OPER	ISIF	CHAN	APPL	SECU	TRAI	PART	SWPR	WORK	MOTI	LANG	REDU
20	59.14	VH	VH	L	H	N	N	L	N	N	L	N	N	L	H	H	VH	VH	VH	VH	N	XH	N	H	H	L	XL	L	N	VH	H	VL	L	XL	VL	XL	N	XL	XL	H	XL	N	N	H
21	7.44	L	VH	L	VH	N	N	L	H	N	L	N	N	L	H	H	VH	L	H	H	N	XH	N	H	H	L	VL	L	N	VH	H	L	L	XL	VL	VL	L	H	VL	H	XL	N	N	H
22	5	L	VH	L	VH	N	N	L	N	N	L	N	N	L	H	H	VH	N	H	H	N	XH	N	H	H	L	XL	L	N	VH	H	VL	L	XL	VL	XL	VL	XL	XL	H	XL	N	N	H
23	9.99	L	VH	L	N	N	N	L	N	XH	L	N	N	L	H	H	VH	L	N	N	N	XH	N	H	H	L	VL	L	L	VH	H	VL	L	XL	VL	VH	VL	L	VH	H	XL	N	N	H
24	55.55	L	VH	L	VH	N	N	L	N	N	L	N	N	L	H	H	VH	L	H	H	N	XH	N	H	H	L	VL	L	N	VH	H	VL	L	XL	VL	L	L	N	VL	H	XL	N	N	H
25	32.56	L	VH	L	H	N	N	L	N	XH	L	N	N	L	H	H	VH	L	H	H	N	XH	N	H	H	L	VL	L	L	VH	H	VL	L	XL	VL	VH	L	H	VH	H	XL	N	N	L
26	2.52	N	VH	L	N	N	N	L	N	XH	L	N	N	L	H	H	VH	N	N	N	N	XH	N	H	H	L	VL	L	L	VH	H	VL	L	XL	VL	VH	VL	L	VH	H	XL	N	N	H
27	30.13	N	VH	L	H	N	N	L	N	N	L	N	N	L	H	H	VH	N	L	N	N	XH	N	H	H	L	XL	L	N	VH	H	VL	L	XL	VL	XL	VL	XL	XL	H	XL	N	N	VH
28	0.27	N	VH	L	N	N	N	L	N	XH	L	N	N	L	H	H	VH	N	N	N	N	XH	N	H	H	L	VL	L	L	VH	H	VL	L	XL	VL	VH	VL	L	VH	H	XL	N	N	H
29	112.3	L	VH	L	VH	N	N	L	N	N	L	N	N	L	H	H	VH	L	H	H	N	XH	N	H	H	L	VL	L	N	VH	H	L	L	XL	VL	L	VL	N	VL	H	XL	N	N	H
30	1.02	L	VH	L	H	N	N	L	N	XH	L	N	N	L	H	H	VH	L	N	N	N	XH	N	H	H	L	VL	L	L	VH	H	VL	L	XL	VL	VH	VL	H	VH	H	XL	N	N	H
31	5.29	VH	VH	L	XH	N	N	L	N	N	L	N	N	L	H	H	VH	L	VL	VL	N	XH	N	H	H	L	VL	L	N	VH	H	VL	L	XL	VL	VL	VL	XL	VL	H	XL	N	N	H
32	25.07	L	VH	L	XH	N	N	L	N	N	L	N	N	L	H	H	VH	L	H	H	N	XH	N	H	H	L	VL	L	N	VH	H	VL	L	XL	VL	VH	VL	XL	VH	H	XL	N	N	H
33	8.8	L	VH	L	H	N	N	L	N	N	L	N	N	L	H	H	VH	L	L	N	N	XH	N	H	H	L	XL	L	N	VH	H	VL	L	XL	VL	XL	VL	XL	XL	H	XL	N	N	H
34	4.02	N	N	H	XH	H	H	N	N	H	H	N	N	L	H	H	VH	H	H	H	N	XH	N	H	H	N	XL	N	N	VH	VH	L	L	XL	H	VL	L	N	L	H	XL	N	N	VH
35	62.78	VL	N	N	XH	H	N	N	N	H	H	N	N	L	H	H	VH	H	H	H	N	XH	N	H	H	L	XL	N	N	VH	H	L	L	XL	N	XL	L	N	L	H	XL	N	N	VH
36	57.77	H	H	VH	XH	H	H	N	N	H	H	VH	N	L	H	H	VH	H	H	H	N	XH	N	H	H	L	XL	N	N	VH	VH	L	L	XL	H	VL	N	N	L	H	XL	N	N	VH
37	19.06	VL	N	N	XH	H	N	N	N	H	H	N	N	L	H	H	VH	H	H	H	N	XH	N	H	H	L	XL	N	N	VH	H	L	L	XL	N	XL	L	N	L	H	XL	N	N	VH
38	24.67	N	N	H	XH	H	H	N	N	H	H	VH	N	L	H	H	VH	H	H	H	N	XH	N	H	H	N	XL	H	N	VH	VH	L	L	XL	H	VH	N	N	L	H	XL	N	N	VH

APPENDIX D

This section provides software effort through software development life cycle and overall software effort. These efforts are used as inputs for establishing estimation models.

Project ID	Plan&Req.	Design	Coding	Testing	Transition	Overall
1	49	111	285	20	21	486
2	41	99	266	15	18	439
3	7	13	102	6	12	140
4	6	14	85	5	10	120
5	18	42	150	10	10	230
6	12	28	120	5	10	175
7	41	62	128	49	26	306
8	50	253	253	30	50	636
9	62	64	89	26	151	392
10	3	30	109	8	3	153
11	45	53	125	14	40	277
12	7	36	129	10	7	189
13	18	113	391	31	14	567
14	8	67	262	16	8	361
15	21	32	71	27	24	175
16	50	45	45	29	33	202
17	78	108	359	42	80	667
18	71	53	71	15	18	228
19	33	45	108	21	27	234
20	26	55	199	11	40	331
21	40	56	105	29	72	302
22	16	26	57	12	9	120
23	45	97	310	33	41	526
24	89	207	332	73	62	763
25	142	182	214	77	179	794
26	18	32	86	11	15	162
27	2	52	140	10	2	206
28	15	39	127	12	15	208
29	61	243	755	61	158	1278
30	33	35	71	10	46	195
31	20	94	263	27	13	417
32	56	111	286	43	35	531
33	9	29	89	9	6	142
34	7	65	25	3	13	113
35	18	238	121	24	21	422
36	13	259	50	61	22	405
37	16	60	69	19	31	195
38	20	9	49	3	11	92

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Pichai Jodpimai, Peraphon Sophatsathit, and Chidchanok Lursinsap, "Analysis of effort estimation based on software project models", in Proc. of the 9th International Symposium on Communications and Information Technology (ISCIT 2009), Incheon, Korea, September 28-30, pp. 715-720, 2009.

Pichai Jodpimai, Peraphon Sophatsathit, and Chidchanok Lursinsap, "Estimating Software Effort with Minimum Features Using Neural Functional Approximation", in Proc. of the 2010 International Conference on Computational Science and Its Applications (ICCSA 2010), Fukuoka, Japan, March 23-26, pp. 266-273, 2010.