DEVELOPING PROTOTYPE COST MODEL FOR EMBEDDED MOTHERBOARDS ASSEMBLY- A CASE STUDY

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ABSTRACT

Organizations today need cost estimation in product early conceptual stage to compete in the market. This study aims to examine the impact of types of components, number of components, memory type, memory size, IPC (Institute for Printed Circuits) class of Printed Circuit Board, types of test/acceptance criteria, number of batch lot sizes, and form factor on the estimated cost of Embedded Motherboard (EM) PCBA (Printed Circuit Board Assembly) at the Prototype Build stage. Learning Curve theory is used as underpinning theory. 77 sample size of suppliers' quotation of different models of EM in the prototype build stage were collected with case study sampling technique used. Multiple regression was performed for data analysis. The results showed that types of components, IPC Class, types of test, number of batch lot sizes, and form factor significantly impacted the total predicted cost. However, number of components, memory type and memory size have insignificant impact on the total predicted cost. The findings furnish significant input to NPD team members to predict prototype PCBA cost despite minimum information at the early design stage. Theoretical implication includes new cost estimation model to improve cost engineering knowledge while practical implication includes cost savings to company in terms of wastage reduction. Practical implication include cost savings to company in terms of wastage reduction. Future research is suggested to embark on an automated parametric cost estimation model to capture, incorporate and store each estimation into a database that can be kept and retrieved for future cost estimation.

Keyword: Parametric cost estimation, embedded motherboard, prototype, printed circuit board assembly.

ABSTRAK

Syarikat pada masa kini memerlukan anggaran kos di peringkat awal konseptual untuk bersaing dalam pasaran. Kajian ini bertujuan untuk mengkaji hubungan langsung antara lapan pemboleh ubah tidak bersandar iaitu jenis komponen, bilangan komponen, jenis ingatan, saiz ingatan,kelas IPC (Institute for Printed Circuits) Papan Litar Bercetak, jenis ujian/ kriteria penerimaan, bilangan saiz lot kelompok dan faktor bentuk dengan anggaran kos EM PCBA dalam Prototaip Binaan sebagai pemboleh ubah bersandar. Teori Lengkung Pembelajaran (Learning Curve) digunakan sebagai teori asas. 77 saiz sampel sebut harga pembekal dari model EM yang berbeza dalam peringkat binaan prototaip telah dikutip dengan teknik persampelan kajian kes digunakan. Analisis menggunakan regresi berganda piawai telah dilakukan melalui perisian SPSS versi 26. Dapatan kajian yang diperolehi daripada model menunjukkan lima IV (jenis komponen, IPC kelas, jenis ujian/kriteria penerimaan, bilangan saiz lot kelompok dan faktor bentuk) mempunyai hubungan yang signifikan dengan jumlah kos ramalan. Manakala baki tiga IV mempunyai hubungan yang tidak signifikan (bilangan komponen, jenis ingatan dan saiz ingatan). Dapatan kajian menyumbang kepada ahli pasukan penyelidikan NPD, yang membolehkan mereka meramalkan kos prototaip PCBA walaupun mempunyai maklumat yang minimum pada fasa awal reka bentuk. Kesan teori termasuk model anggaran kos baru untuk meningkatkan pengetahuan kejuruteraan kos manakala kesan praktikal termasuk penjimatan kos kepada syarikat melalui pengurangan pembaziran. Kesan praktikal membantu penjimatan kos kepada syarikat melalui pengurangan pembaziran. Penyelidikan yang dicadangkan pada masa akan datang termasuk model anggaran kos para metrik automatik yang membenarkan setiap anggaran diambil, digabung dan disimpan dalam pangkalan data serta dirujuk untuk anggaran kos masa hadapan.

Kata kunci: anggaran kos para metrik, papan induk terbenam, prototaip, pemasangan papan litar bercetak.

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LIST OF ABBREVIATIONS

ABC	Activity Based Costing
ANN	Artificial Neural Network
BOE	Base of Estimate
CER	Cost Estimation Relationship
CFT	Cross Functional Team
CM	Contract Manufacturer
CPU	Central Processing Unit
DTC	Design to Cost
EM	Embedded Motherboard
EMS	Electronics Manufacturing Services
EVM	Earning Value Management
IoT	Internet of Things
IPC	Institute for Printed Circuits
NPD	New Product Development
ODM	Original Design Manuafcturer
OEM	Original Equipment Manufacturer
PC	Personal Computer
PCB	Printed Circuit Board
PCBA	Printed Circuit Board Assembly
RFQ	Request for Quotation
SKU	Stock Keeping Unit

CHAPTER ONE : INTRODUCTION

This chapter aims to give an introduction to the readers on the dissertation and also on the research topic. The research context is explained and the problem statement will be elaborated. The cost estimation relationship (CER) for embedded motherboard will be established using a cost model framework.

After defining the research problem, the objectives and motivation for the research will be established. Lastly, the dissertation structure will be explained to provide readers with general insights of the research.

1.1 Background of research

Cost is important to determine the survival of the businesses which manufacture products, deliver services and mixture of both products and services. In order to stay competitive in today's market, companies need to be capable of generating products or services not only in best quality but also at lowest cost. Organizations with ability to generate cost estimates in early conceptual design stage have lesser percentage of new projects behind schedule and also incur lower development cost compared to organizations without cost estimates (Wang & Potter, 2007). This is why cost estimation is important. Cost estimation includes the subset of controlling and estimating cost together with business planning as well as

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APPENDIX A: CODING LEGEND FOR SUPPLIER QUOTATION

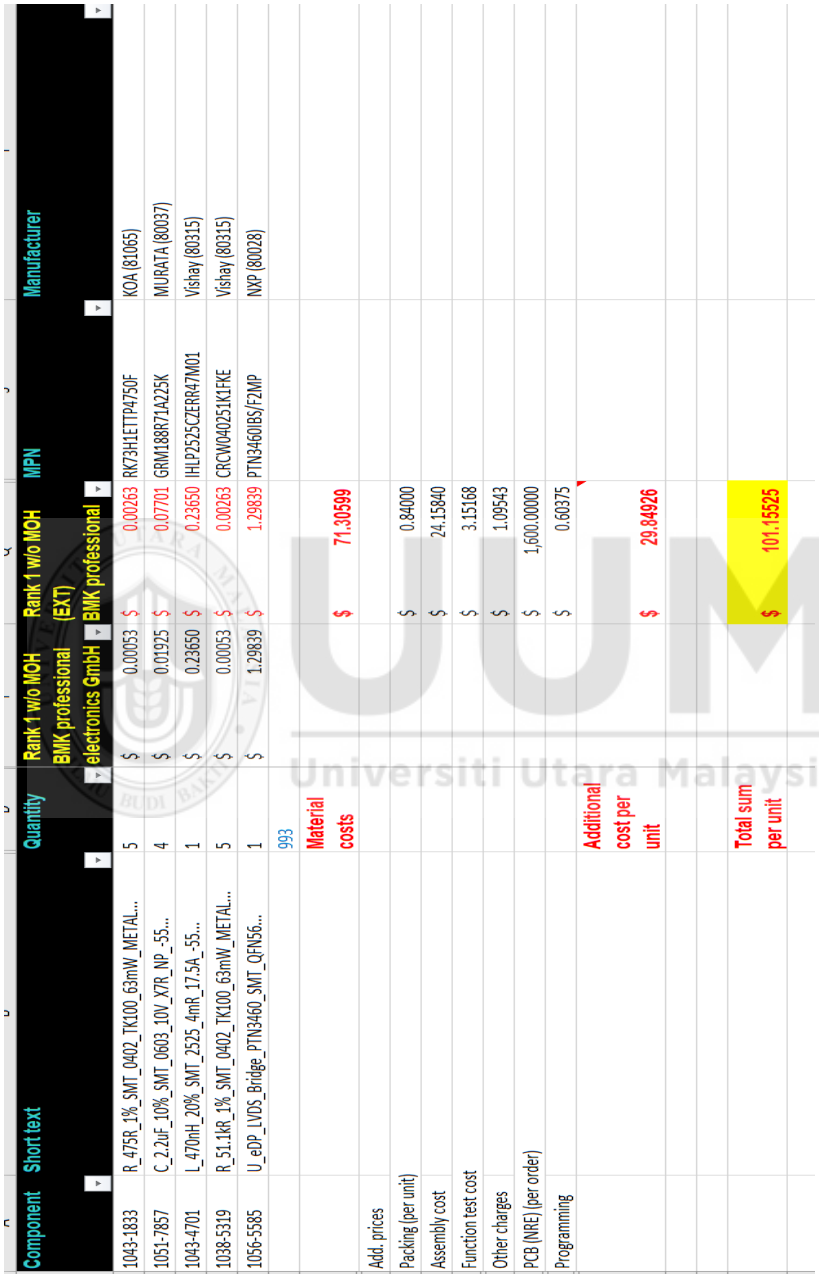
Variable Name (SPSS)	Variables	Values	Coding (Ordinal)
Typecomp	Types of components in motherboard PCBA	1-10 ICs no micro BGA	1
		1-20 ICs no micro BGA	2
		1-20 ICs , 1 micro BGA	3
		More than 20 ICs with micro BGA	4
NumbComps	Number of components in the motherboard PCBA	0-20	1
		21-50	2
		51-100	3
		101-300	4
		More than 300	5
Memorytype	Memory type used in motherboard PCBA	ROM	1
		RAM	2
		EPROM	3
		FLASH	4
		OTP	5
Memorysize	Memory size used in motherboard PCBA	8 kB	1
		16 kB	2
		32kB	3
		64kB	4
		128kB	5
		256kB	6
		512kB	7
		1 MB or more	8
		10 to 20 MB	9
		20 to 30 MB	10
		More than 30 MB	11
IPCClass	IPC Class of PCB used	IPC 6012 Class 1	1
		IPC 6012 Class 2	2
		IPC 6012 Class 3	3
Testtypes	Types of test performed	No Test	1
		In circuit test (ICT)	2

Variable Name (SPSS)	Variables	Values	Coding (Ordinal)
		functional test (FT)	3
		AOI Programming	4
		(5DX/ AXI Programming)	5
		Both AOI and 5DX Programming	6
Batchsize	Batch size per build	1 to 5	1
		6 to 10	2
		>10	3
Formfactor	Form factor (size)	KTQ87 (228.6 mm x 190.5 mm)	1
		Mini- ITX (170 mm x 170 mm max)	2
		COM Express (125 mm x 95 mm)	3
		Pico-ITX (100x 72 mm max)	4
		SMARC (82 x 50 mm)	5
		Kbox (210 x 65 x 140 mm)	6

APPENDIX B: SAMPLE OF SUPPLIER QUOTATION SUMMARY

			Value	**Grouping per research**	**CODED**
Quote session	0717-0006-QS	**Types of components in motherboard PCBA**	23 IC s + Intel Atom Microbga processor	More than 20 ICs with micro BGA	4
Material	36024-0000-13-5 (Rev. 0B0207 ALT(01))	**Number of components in the motherboard PCBA**	993 components	More than 300	4
Material short text	COMe-cAL6 E2 E3930 PRESERIES	**Memory type used in motherboard PCBA**	FLASH	FLASH	4
Quantity	150	**Memory Size**	128Mb	More than 30 MB	11
Delivery address		**IPC Class**	IPC 6012 Class 2	IPC 6012 Class 2	2
Contact person	Birgit.Gstettenbauer	**Types of test performed**	Function Test Cost $ 3.15168	functional test (FT)	3
		Batch Size	2000	>10	3
		Form Size Factor	125 mm x 95 mm	COM Express (125 mm x 95 mm)	3

APPENDIX C: SAMPLE OF SUPPLIER QUOTATION



Component	Short text	Quantity	Rank 1 w/o MOH BMK professional electronics GmbH		Rank 1 w/o MOH (EXT) BMK professional		MPN	Manufacturer
1043-1833	R_475R_1%_SMT_0402_TK100_63mW_METAL...	5	$	0.00053	$	0.00263	RK73H1ETTP4750F	KOA (81065)
1051-7857	C_2.2uF_10%_SMT_0603_10V_X7R_NP_-55...	4	$	0.01925	$	0.07701	GRM188R71A225K	MURATA (80037)
1043-4701	L_470nH_20%_SMT_2525_4mR_17.5A_-55...	1	$	0.23650	$	0.23650	IHLP2525CZER47M01	Vishay (80315)
1038-5319	R_51.1kR_1%_SMT_0402_TK100_63mW_METAL...	5	$	0.00053	$	0.00263	CRCW0402511KFKE	Vishay (80315)
1056-5585	U_eDP_LVDS_Bridge_PTN3460_SMT_QFN56...	1	$	1.29839	$	1.29839	PTN3460IBS/F2MP	NXP (80028)
		993						
		Material costs			$	71.30599		
Add. prices								
Packing (per unit)					$	0.84000		
Assembly cost					$	24.15840		
Function test cost					$	3.15168		
Other charges					$	1.09543		
PCB (NRE) (per order)					$	1,600.00000		
Programming					$	0.60375		
		Additional cost per unit			$	29.84926		
		Total sum per unit			$	101.15525		