SELECTION OF ELECTRICAL ACCESSORIES: A "COST MODELLING" APPROACH

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Abstract: Electrical installations contribute to 6% -10% of the total cost of a typical house. Therefore, the selection of the most appropriate electrical accessories is very important from the client's point of view. But lack of information about the products and prices makes these decisions very difficult for clients to make. Development of a product-cost model for the selection of electrical accessories could be seen as one of the solutions for this problem. Thus the authors have developed a product-cost model for the selection of electrical accessories for housing constructions in Sri Lanka.

A market survey and a series of interviews were conducted in order to collect cost and product data pertaining to electrical accessories used in Sri Lankan domestic electrical installations. All the accessories identified were classified into five main categories based on their functionality. In the data analysis, three main cost categories were identified. On the other hand, three different designs were selected to represent the collection of accessories in a typical domestic electrical installation. Finally, a simple decision support system was developed as the front end for the developed product-cost model.

Keywords: Cost Modelling, Decision Support System, Electrical Accessories.

1. BACKGROUND

Electricity was a luxury for houses in the past, but it is a necessity for each and every house, irrespective of the scale or the category of the household. Within the Sri Lankan construction industry, the installation cost of an electrical system in a building has a significant contribution to its cost. Sri Lankan housing construction is not an exception within this context.

Unlike other items of a house, the individual house builders (clients who employ direct labour to build their own houses) are naturally reluctant to identify their requirements on purchasing electrical accessories. According to Lawrence (1993) the electricity supply is one of the essential elements of the home that seems to strike fear into the hearts of individual house builders everywhere. This fear and unawareness may lead to undue costs in domestic electrical installations. Hence, it has become apparent that the client should be made knowledgeable about the domestic electrical accessories in order to optimise the domestic electrical installation costs. The key barrier to this is the low confidence of individual house builders and lack of proper reference points regarding the cost, quality and the functionality of electrical accessories in the market. The complexity of the technology and safety concerns keep the electrician, rather than the client, in the commanding position within this process, which makes the individual house builders feel uncomfortable in decision-making.

To solve this problem, a huge boost in confidence of the client's decision making is necessary. Accordingly, there should be a solid base for comparison of information and facts. A cost model may provide an acceptable solution within this scenario. As identified by Beeston (1987), "A cost model's task is to estimate the cost of a whole design or of an element of it, or to calculate the cost of effect of a design change." Authors have used this approach to solve the above problem and adopted the following methodology to build a product-cost model with the aim of addressing the above mentioned problem.

2. RESEARCH METHODOLOGY

Having identified the need for a cost model for the selection of electrical accessories, information about the existing electrical accessories in the market was collected, by means of interviews with suppliers and manufacturers. For this purpose, marketing managers of 3 major electrical accessory manufacturing companies (Sri Lankan branches) were interviewed. Further references were subsequently made to collect technical specifications of these accessories based on published sources. Further 4 unstructured interviews with industry professionals were conducted to find information and views about quality standards of electrical accessories in use. Further, all the collected information were categorised according to the basic functions of the accessories. Thirdly, accessories were evaluated in terms of costs and qualities and were ranked accordingly under relevant categories. Cost model was subsequently developed based on the collected information. Finally, a computer-based simple Decision Support System was developed, as the front end of this cost model, using an object oriented programming language: Visual Basic. Further, a website was also created in order to publish information pertaining to electrical accessories.

Prior to the process of building the cost model, a literature survey was conducted to identify the nature of building cost models and the methods in use.

3. WHAT IS COST MODELLING?

As the name implies, Cost Modelling is a technique which is used to model the cost of a system. More comprehensive definition has been given by Ferry and Brandon (1999) by stating; "Cost Modelling may be defined as the symbolic representation of a system, expressing the contents of that system in terms of factors which influence its cost" (Ferry and Brandon, 1999). By looking at the practical aspects of the Cost Modelling, Smith (1989) has stated that, with the development of Cost Modelling systems, the quantity surveyor is not only be able to represent the total cost profile of a project but also to interact with the model; to indulge in 'what if' simulations as the design progresses to ensure the minimal gap between the client's requirement and the completed scheme. The cost models which are used for 'what if' simulations are often known as parametric cost models. Parametric cost models are made up of one or more algorithms or cost estimating relationships (CERs) that translate technical and/or programmatic data (parameters) about a product or asset into cost results (The Association for the Advancement of the Cost Engineering, 2004) Further, Ferry and Brandon (1999) has identified several features that should be contained in a good cost model:

- Provide cost information quicker
- Provide more information
- Provide more reliable cost information
- Provide information at an early stage in the design process
- Provide information in a more understandable manner

Cost Models can further be used as a tool in the decision making process. Ferry & Brandon (1999) have represented the role of models in the decision making process as follows. (See Figure 1)

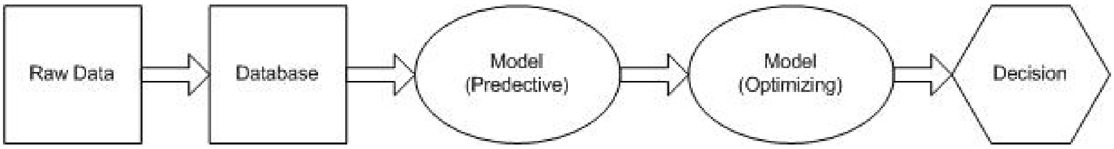

Figure 1-Role of models in the decision making process - (Ferry & Brandon, 1999)

Building a cost model involves a systematic approach. Common methodologies for cost model building are described below.

3.1 Methods of building cost models

Ashworth (1989) being one of the leading researchers in the field of cost modelling has mentioned two major categories of forecasting costs.

- Deductive method - Use statistical analysis of previous performance data as the basis for cost modelling. Usually uses the regression analysis as the tool for measuring the association between data.
- Inductive method - A method of predicting the cost by using detail cost breakdowns.
- Further he highlights four major methods of building cost models.
- Empirical methods - These types of models are based upon observations, experience, and intuition. In this method it is usually assumed that there is a fixed relationship between the design variables and cost, and which have been derived from observation and experiment. (Ferry & Brandon, 1991)
- Algorithmic methods - Algorithms include a number of step by step procedures for determining the optimum values of variables in model building (Ashworth, 1989). Regression analysis is one of the techniques used in building algorithmic cost models. Since there is always a rationale behind model building, these models can create a confidence in the user's mind. Unlike in the empirical method, this particular method often consists of tedious calculations which require a high degree of mathematical and statistical knowledge.
- Simulation method - A simulation model seeks to duplicate the behaviour of the system under investigation by studying the interaction among its components. For a cost model to be successful as a creative design tool, rather than being a passive monitor of cost, a mathematical modelling technique is required to simulate a large number of possible solutions and provide a comparative evaluation of these so that the best solution can be indicated (Brown, 1987).

This necessity of a simulation method for building a cost model can be fulfilled by using the Monte Carlo technique. Ashworth (1989) has identified this method as very useful in dealing with complex problems. As disadvantages, the inherent drawbacks of statistical analysis can be highlighted.

- Heuristic method - These models are based on 'rule of thumb' procedures. In Contrast with the algorithmic method, those procedures are not based on statistical analysis. This approach has the advantage of being less complex in mathematical terms. But, since these types of models have inbuilt behavioural characteristics of the modeller, the reliability of the model is doubtful.

Since this cost model is aiming at a knowledge transferring activity (transfer of sufficient decision making knowledge of the expert to the end user) the development is influenced by empirical and heuristic methods.

4. DEVELOPMENT OF THE COST MODEL

Typically there are several common factors considered by most individual house builders when selecting appropriate electrical accessories. Some of those were identified during the unstructured interviews conducted by the authors with experts in the industry, and with some individual house builders. They are: the cost, aesthetic appearance, safety and durability, and quality assurance – (manufactured country, brand name, recommendations of experts, standards, etc.)

However, the priority of the list of these features varies with the situation and the characteristics of the person with the need. In the selection process of the electrical accessories for a domestic electrical installation, for the ease of reference, all the accessories can be grouped into five main categories (Lawrence, 1993).

Accessories in power circuits

- Accessories in lighting circuits
- Protective devices
- Accessories in other circuits
- Cables and other sundry items

Each of these categories comprise of several key accessories, as listed within the table 1 below:

Table 1-Electrical Accessories in main groups - Lawrence, (1993)

Group	Accessories
Accessories in power circuits	Socket outlets, Shaver Sockets, Cooker Controllers
Accessories in lighting circuits	Switches, Light Dimmers, Lamp Holders, Ceiling Roses, Light fittings
Protective Devices	Miniature Circuit Breakers, Residual Current Circuit Breakers, Earth Terminals
Accessories in other circuits	Telephone Sockets, Television Antenna Sockets, Bell Switches, Electrical Bell Units, Ceiling Fans
Cables and other sundry items	Wiring Cables, Conduits, Conduit Accessories, Enclosures, Cable Trunks, Junction Boxes, Sunk Boxes, Wiring Clips

Due to the diversification of availability of different types of accessories, a systematic approach should be adopted in the process of building the model. Several procedures can be adapted to this effect and the authors followed the following three steps in building this particular cost model:

- Identification of the Cost Variables
- Collection and analysis of cost and product data
- Representation of analysed data in the model in a way that it reflects the cost variables of the system, while catering to the need of ease of use of the model and ability of simulating various combinations

4.1 Identification of Cost Variables

Identification of cost variables is one of the most important tasks in developing a cost model. The whole success is dependant upon the ability of the modeller to identify the correct and all the cost variables in the system. In developing this particular model, two basic streams were identified as major cost variable streams:

Types of accessories to be incorporated to the electrical installation – Unlike in most of other elements of a house, the electrical installation has variety of optional accessories which significantly influence the cost of the installation. The decision to incorporate or omit those optional accessories in the installation will have a definite cost impact; and

Cost Category of electrical accessories – It is one of the salient features of the electrical accessories market that the prices of accessories available have a huge range of variation even if the accessory gives the same functionality. Hence, the household's choice of the cost category of the accessory is the other crucial factor which influences the cost of the installation.

During unstructured interviews held by the authors, the interviewees' perception towards the cost variables in this regard is questioned and the above stated outcomes are based on those interviews.

4.2 Collection and analysis of the cost and product data

Cost data required to build this cost model was collected through a market survey. Three categories of sources were identified for data collection purposes. Those are: leading manufacturers and distributors of electrical accessories in Sri Lanka, retailers of electrical accessories located within the Colombo city limits and the suburbs and electricians who provide labour for domestic electrical installations. Data collection is based on obtaining price lists and product catalogues from leading electrical manufacturers, importers and distributors operating within the country, price lists obtained from retailers and data obtained from domestic electricians regarding the labour charges. Prices for all the electrical accessories were collected from several places subjected to a maximum of five places per accessory.

During the price analysis, mean of all the prices pertaining to a single accessory is calculated and taken as the price for that particular accessory. When prices were not available for a particular cost category of an accessory, price of the "Standard" cost category of the same is substituted. Usage of accessories in these respective designs is unique to the design and can be tabulated as table 2 below. In this, the 'usage' describes a final circuit. Necessary accessories, cables and sundry items are included in a final circuit (please refer table 2 below)

4.3 Data Modelling

Prior deciding on methodology of analysis and modelling, ideas and views were taken from the experts in the industry. Five unstructured interviews were held with marketing managers and other officials in leading electrical accessories manufacturing, importing and distributing companies in Sri Lanka. Accordingly, two major approaches were followed as the basis for modelling the collected data:

Table 2-Number of final circuits and accessories in respective designs

Category of accessories	Usage	Basic	Moderate	Complex
Power Circuits	5A Socket outlets	5 Nos.	8 Nos.	13 Nos.
	13A Socket outlets	-	6 Nos.	10 Nos.
	15A Socket Outlets	1 No.	1 No.	2 Nos.
	Shaver Sockets	-	-	2 Nos.
	Cooker Controllers	-	-	1 No.
Lighting Circuits	Pendent lamp with switch	8 Nos.	4 Nos.	4 Nos.
	Wall Bracket lamp with switch	2 Nos.	6 Nos.	10 Nos.
	Ceiling Lamp with switch	-	2 Nos.	2 Nos.
	Wall Bracket Lamp with 2 way switch	-	-	1 No.
	Pendent lamp with chandeliers with Dimmer	-	1 No.	2 Nos.
Protective Devices	Consumer Unit (Distribution Board)	1 No.	1 No.	1 No.
	Earth Electrode	1 No.	1 No.	1 No.
Other Circuits	Telephone Sockets	-	2 Nos.	8 Nos.
	Television Sockets	-	-	3 Nos.
	Door Bell	1 No.	1 No.	1 No.
	Gate Bell	-	-	1 No.
	Ceiling fans	1 No.	6 Nos.	8 Nos.

1. Selection of three main designs of electrical installations to represent the various combinations of usages of electrical accessories in housing electrical installations, namely,

- Basic - Represents most important and primary accessory requirement in the basic capacity
- Moderate – Represents a typical domestic electrical installation within the Sri Lankan context, where all the important and basic accessories are included and some of the optional accessories are also included

- Complex – Represents a fairly comprehensive domestic electrical installation in Sri Lankan standards

2. Categorisation of cost of accessories in three main ways to represent the cost implication of the selection of each cost category. Those categories are named as,
   - Economical
   - Standard
   - Luxury

Each cost category represents the cost of accessories in different amounts. Those can be represented in a tabulated format as below (Table 3). Costs of final circuits mentioned in the 'Economical', 'Standard', and 'Luxury' column are calculated with respect to final circuits mentioned in the 'Usage' column by applying the costs of accessories in their respective cost categories.

Table 3-Composite rates for final circuits

Category of accessories	Usage	Economical (Rs)	Standard (Rs)	Luxury (Rs)
Power Circuits	5A Socket outlets	725.00	827.00	1,016.00
	13A Socket outlets	999.00	999.00	1,171.00
	15A Socket Outlets	967.00	1,060.00	1,249.00
	Shaver Sockets	2,969.00	2,969.00	4,568.00
	Cooker Controllers	1,194.00	2,094.00	3,344.00
Lighting Circuits	Pendent lamp with switch	540.00	563.00	591.00
	Wall Bracket lamp with switch	804.00	987.00	3,615.00
	Ceiling Lamp with switch	804.00	1,118.00	3,055.00
	Wall Bracket Lamp with 2 way switch	842.00	1,016.00	3,783.00
	Pendent lamp with chandeliers with Dimmer	2,451.00	4,623.00	25,630.00
Protective Devices	Distribution Board	3,216.00	7,710.00	10,036.00
	Earth Electrode	706.00	706.00	706.00
Other Circuits	Telephone Sockets	781.00	944.00	1,211.00
	Television Sockets	846.00	1,015.00	1,156.00
	Door Bell	869.00	1,101.00	2,071.00
	Gate Bell	1,331.00	1,513.00	2,313.00
	Ceiling fans	3,108.00	3,108.00	6,041.00

Tables 2 and 3 above provide the basis for a simulation of the cost variation with the change of either the product category (economical, standard and luxury) or the design category (basic, moderate or complex). The following graph shows the result of the simulation when both the parameters are changed with respect to each other.

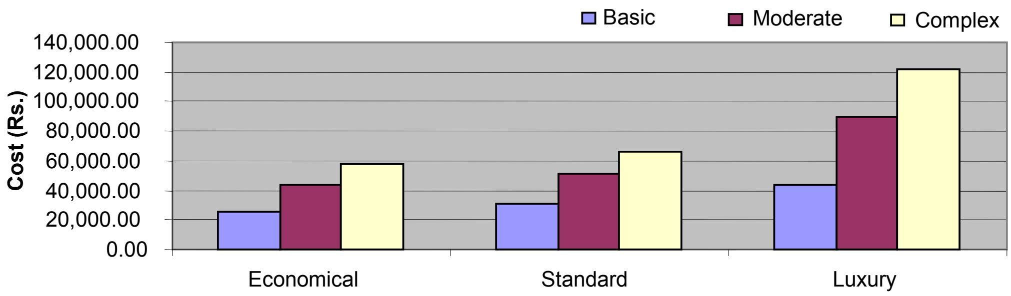

Figure 2-Comparison of cost differences with the change of both the design and the Cost category

From the graph it is visible that the difference between the economical and standard cost categories is marginal where as the luxury cost category shows a noticeable deviation. This fact is further discussed within the conclusions.

5. USER INTERACTION AND THE FUNCTIOANLITY OF THE COST MODEL

When using this Cost Model, the user interaction and the functionality can be represented as shown in the Figure 3.

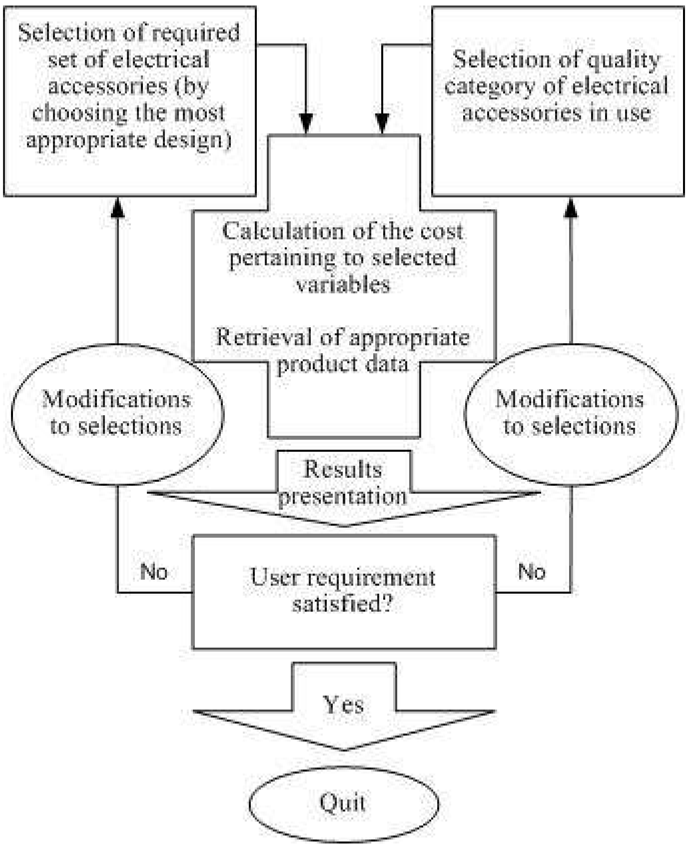

Figure 3-User interaction and the functionality of the cost model

As the dissemination method of this Cost Model, authors developed a computer based simple Decision Support System. The functionality of the Decision Support System can be illustrated as follows:

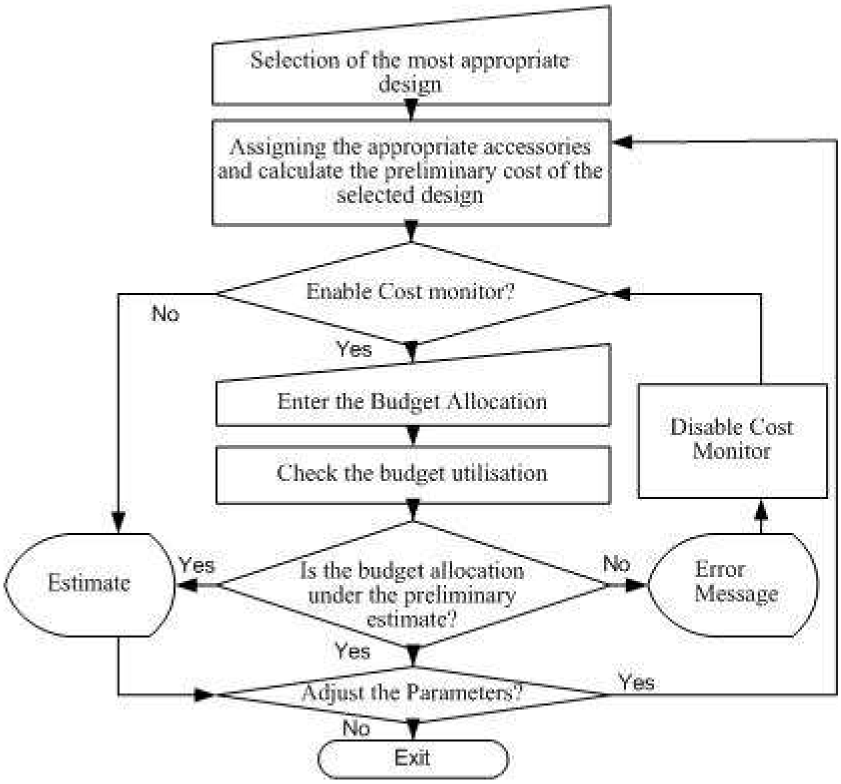

Figure 4-The DSS Functionality

Some of the special facilities that could be arranged in this mode of dissemination of the Cost Model are:

- By selecting the most appropriate in-built design to match with the real situation, the system will instantly calculate and determine the needed accessories for the installation and its cost.
- By providing the option of enabling and disabling the 'cost monitor' facility, the system allows the user to restrict or neglect the selection of accessories according to its cost.
- By providing instance error messages regarding the insufficient fund allocation in the budget, the user will be able to have an instant idea about the minimum fund requirements pertaining to particular type of installation.
- By providing instant on-screen cost breakdown facility, the system allows the user to determine its own cost components.
- With the graphical cost monitor the user is able to graphically see the allocated percentage of budget to the installation at a given situation.
- The On-line web based product and cost information system allows the user to find relevant technical information and costs of accessories used for the installation.
- Single Price Database allows developers and users to easily update the prices when necessary.

As a method of improving the availability of technical information with respect to Electrical Accessories, a website was developed by the Authors. This gives some added benefits to the user:

- Availability of the information world wide at any given time
- Flexibility to update and insert timely information, like new innovations in the industry

6. CONCLUSION

Within the Sri Lankan context, lack of confidence, lack of knowledge and safety concerns are the major barriers between the selection of proper domestic electrical accessories and the end user. In this research, Cost Modelling is used as a solution for this problem. The developed cost model is used as a simulation tool to understand the patterns of the Sri Lankan domestic electrical accessories price variations.

It is clear from the data analysis that the cost difference in any design, when using electrical accessories in “Economical” and “Standard” cost categories is marginal comparatively to that of “Standard” and “Luxury”. In fact, the percentage cost increase between the “Economical” and “Standard” cost categories is 23% in the Basic Design, where as the cost increase between the “Standard” and “Luxury” cost categories is 41%. The situation become more clearer when considering the Moderate & Complex Designs, where the percentage cost increases between the “Economical” and “Standard” cost categories are 15% and 14 % respectively, and the cost increase between the “Standard” and “Luxury” cost categories are 75% and 84% respectively.

From the composition of categories of electrical accessories in different designs and different Cost Categories, it can be seen that with the change of Basic Design to Complex Design and Cost Categories from “Economical” to “Luxury”, the ‘Protective Devices’ category contribution has dropped from 15% to 5%. Hence, the increased cost was less influenced by Protective Devices. This may be very useful to encourage house holders to consider use of high quality protective devices even in low cost electrical installations, as it may ensure one key aspects of electrical installations, the safety.

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