International Journal of Engineering Science Invention
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 6 Issue 7|| July 2017 || PP. 20-25

Evaluation of Facilities Layout alternatives by integrating concepts of ABC & AHP

G. Shashikumar *, B. Sarkar ** and S.K. Sanyal **
** B.M.S. College of Engineering, Bangalore – 560 019, India, shashi_kg1@yahoo.co.in*
*** Production Engineering Deapartment, Jadavpur University, Kolkata – 700 032, India*
Corresponding Author: G. Shashikumar

Abstract: *Modern-day manufacturing operations are facing a fierce global competition and the need to increase productivity at reduced cost. Estimating various manufcturing costs more accurately has become a strategic objective. An ever increasing number of organsations are using Activity Based Costing (ABC) to handle manufacturing activities and processes as well as product costing. The natural logic of ABC can also be applied for making important strategic decisions. This paper presents a methodology that ties investment analyses of Facilities Layout (FL)s to ABC concepts using Analytical Hierarchy Process (AHP). By using a multi-criteria decision making method as AHP, both monetory and non-monetory benefits can be included in the analysis. Initially the relationships between goals, activities and cost are developed, then they are combined to make a model, integrating ABC and AHP. The goal of the decision process is to evaluate alternative FLs based on the activities and their contribution to overall organisational goals.*

Notations: *Activity Based Costing (ABC), AHP, MCDM, Facilities Layout (FL)*

Date of Submission: 05-07-2017 Date of acceptance: 20-07-2017

I. Introduction

Modern production methods viz., CIM, FMS are aimed at optimizing the processes, resource utilisation and bringing down overall production cost. The emergence of the new areas such as cognitive science are defintely aimed at solving various industry related problems. The use of ABC to determine cost of products has gained wide acceptance in recent years. In traditional cost accounting systems, indirect costs are assigned to products using direct labour hours or some other unit-based measure to determine overhead costs. Thus traditional cost accounting does not accurately represent cost when a large productivity gain has been made. Other types of distortion caused by the traditional cost accounting system are concerned with timing; example, R&D costs of future products are charged to products currently being produced etc. For such reasons a new way of assigning indirect cost called ABC has been developed.

Also AHP quantifies decision-makers' subjective judgements by assigning corresponding numerical values based on the relative importance of the components under consideration. The magnitude of dominance or preference shows the strength of preference in the pair-wise comparison and pair-wise comparison matrices are developed. These Multi-Attribute Decision Making (MADM) technique that accounts for various subjective parameters helps in making an effective decision regarding selection of a FL.

The purpose of this paper is to develop an algorithm to select a proper FL for a particular production. The procedure follows few steps. First, the relationships between goals, activities and costs are defined using AHP technique. Next the relationship between the costs and activities is developed using ABC. Further, the selection of a particular FL is made using the combination of both.

II. Prior Art

Various researchers have carried out commendable work in the field of project cost evaluation. Luong and Spedding (1995) developed a generic knowledge-based system for process planning and cost estimation for hole making. Takakuwa(1997) utilised simulation to estimate cost for a Flexible Manufacturing System(FMS) based on ABC analysis. Aseiedu et al. (2000) considered the uncertainties associated with the cost model parameters such as time, inflation, labour rates and failure rates by employing non-parametric estimation techniques. Some cost analyses of manufacturing operations use features(design & manufacturing building blocks) technology. Also, some researchers have found usefulness in adopting parametric cost estimation methods.

A relatively new cost estimation approach is the ABC method. Park and Kim(1995) have carried out appreciable work by making a thorough review and comparison of traditonal cost accounting and ABC analysis. This analysis is often used as a part of total cost management. ABC has been applied to various industries(Tsai,

1996) such as electronics (Merz & Hardy, 1993), automotive engineering(Miller, 1994), aerospace & defence(Soloway, 1993), telecommunication(Hodby et al.,1994). The ABC method is found identify the activities that drive costs by consuming resources.

The shortcomings of ABC methods include the following : doing little to change old management behaviour, not driving companies to change their fundamental views about how to organise work and to satisfy customers efficiently. Finally, the ABC method requires additional effort and expense in obtaining the information required for the analysis(Lewis, 1995).

III. Activity Based Costing (ABC)

Activity based costing, as the name suggests, it traces costs of products through activities. Activities, rather than products consume resources and the demand for those activities in the manufacturing process determines how the costs are allocated to the individual products. Rather than assigning costs to an arbitrary reference like direct labour hours or machine hours, ABC assumes that products incur costs by *activities* that are required for their design, manufacture, sale, delivery and service. In turn, these activities create cost by consuming support services such as engineering design, production planning, machine setup and product packing and shipping. To implement an ABC system, one must identify the major activities undertaken by the support departments and select a *cost driver* for each.

This two stage allocation scheme that uses various cost drivers such as engineering hours, number of setups, number of orders placed, number of inspection, etc. is the highlight of ABC. Hence cost allocation is no longer limited to material or labour usage and the biggest difference with traditional cost accounting system is on overhead allocation. Thus the focus of ABC is not on the end product but on the manufacturing process and the activities required to manufacture the product. Cooper et al. (1992) and Brimson (1989) discussed Activity Based Management (ABM) as a management process that uses ABC information. This is a key to process improvement. Sawhney (1991) has developed a methodology for evaluating manufacturing investment, in general that are heavily influenced by non-financial considerations.

We propose to formalise the definition of difference between manufacturing goals, activities and investment decision with regard to FL by using AHP. This method provides a more consisting weighting scheme than other scoring techniques (Chan and Lynn, 1993). We will then use ABC to develop the cost relationship between alternatives and activities. Once these relationships have been established we will incorporate them in the decision model.

IV. Analytical Hierarchy Process (AHP)

Any system is to be studied under conflicting and co-operating attributes of that system. The effect of each attribute on the overall functioning of the system is of paramount importance. As the number of attributes influencing the working of the system go on the rise, the process of establishing effectively the effect of individual and interacting attributes becomes complicated. The model becomes complex. To model such a real time system by attaching 'weights' to attributes affecting the system performance, AHP comes in handy. AHP allows Pair wise Comparison (PWCP) and aids in Consistency Study in judgments (decision making). Hence AHP is a powerful tool for MCDM. Here weight setting is a difficult task, if the number of attributes is more. The fundamental steps involved in AHP are:

- The problem is to be structured as a hierarchy of overall objective
- PWCP is to be made to establish Dominancy
- Weight Calculation is to be done (priority evaluation)
- Consistency must be verified. To integrate the priorities to converge at an overall evaluation of decision alternatives.

The nine point scale developed by Saaty (1994) is shown in the table-1.

Table 1: The scale of pairwise comparison

Intensity of relative importance	Definition
1	Equal importance
3	Preferred (Moderately)
5	Preferred (Essentially)
7	Preferred (Very strongly)
9	Preferred (Extremely)
2, 4, 6, 8	Intermediate importance between two adjacent preferences

The concept of relative importance is used to assign weights to alternatives as well as criteria for constructing the Decision Matrix (DM) and PWCP matrices to arrive at decision-makers' preferences. The intensity scale of importance introduced by Saaty, 1994, has been used here.

The DM and PWCP matrices used in AHP are all square matrices. The consistency of judgment values assigned to the decision alternatives and criteria are checked using Eigen values and Eigen vectors. Based on these indices the decision-makers revise and modify the judgment values, if required.

V. Decision Model

The methodology consists of the following steps:

Step1: Define the relationship between activities and strategic goals by using AHP technique to rank activities in terms of strategic goals.This step also defines the relative importance of the strategic goals.

Step2: For each alternative FL, determine the net effect on the reasources, including capital investment. Distribute this net effect from resources to activities using ABC techniques.

Step3: Combine steps 1& 2 into a 'cost-effect' model to determine the cost score for each FL alternative.

Step4: Using AHP techniques of relative interraction of attributes, find out the weightings for each of the layout options.

Step5: Select the FL with the highest weighting score even if, the overall savings may be high for some other FL.

The model is conceptualised as hereunder:

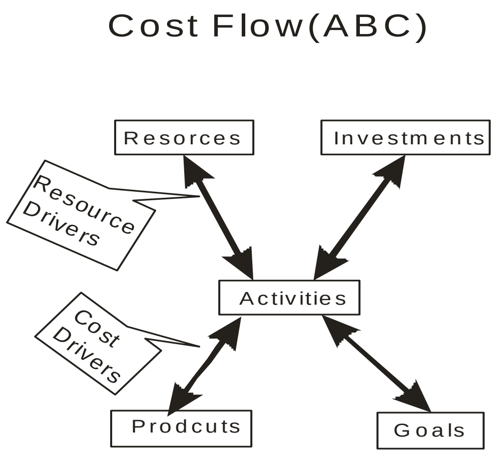

Figure 1: Cost-effect model to develop alternative FLs

VI. A Case Study

A management of a mass production firm is interested in improving its capacity, quality and productivity, to improve its flexibility, to eliminate bottle necks. It wishes to evaluate 5 alternative FLs for this purpose. Each of this FLs studied use 6 important cost factors and corresponding cost drivers. The output estimated by each of the 5 layouts are different. The challenge is to make a proper choice amongst these five to suit a particular type of production environment. The management has computed the equivalent annuity (on a monthly basis) for developing the cost components of the 5 layouts. The activities and their corresponding cost drivers are listed in table 2.

Table 2 : Cost heads

Activity	Cost Driver	Rate
Cost of Engineering Design	Hours of Engineering Services	@$ 2500 per hour
Cost of Production Setups (Installation Cost)	Number of Setups	@$ 5000 per setup
Cost of Material Handling	Number of Components	@$ 17.50 per component
Cost of Improvement and Development	Number of units added	@$ 1850 per unit
Cost of Inspection	Hours of Testing	@$ 2000 per hour
Cost of Maintenance	Number of Machines	@$1250 per machine

The activity of the cost drivers are obtained from the cost records. The table 3 records the details regarding the cost drivers for alternative FLs as listed below.

Table 3: Cost Drivers

Cost Drivers	FL_1	FL_2	FL_3	FL_4	FL_5
Number of components	620	360	120	480	290
Hours of Engineering Service	6	4	0.9	5	10
Production Batch Size	1000	1500	2900	1900	3100
Hours of Testing	1.8	2.3	4	2	1.6
Units in Production	28	20	25	22	19
Additional Units	8	5	2	10	4

In building the cost comparison between FLs, we turn to ABC for allocating overhead costs.

Using AHP techniques, the following priority weights for strategic end goals and corresponding activities were worked out.

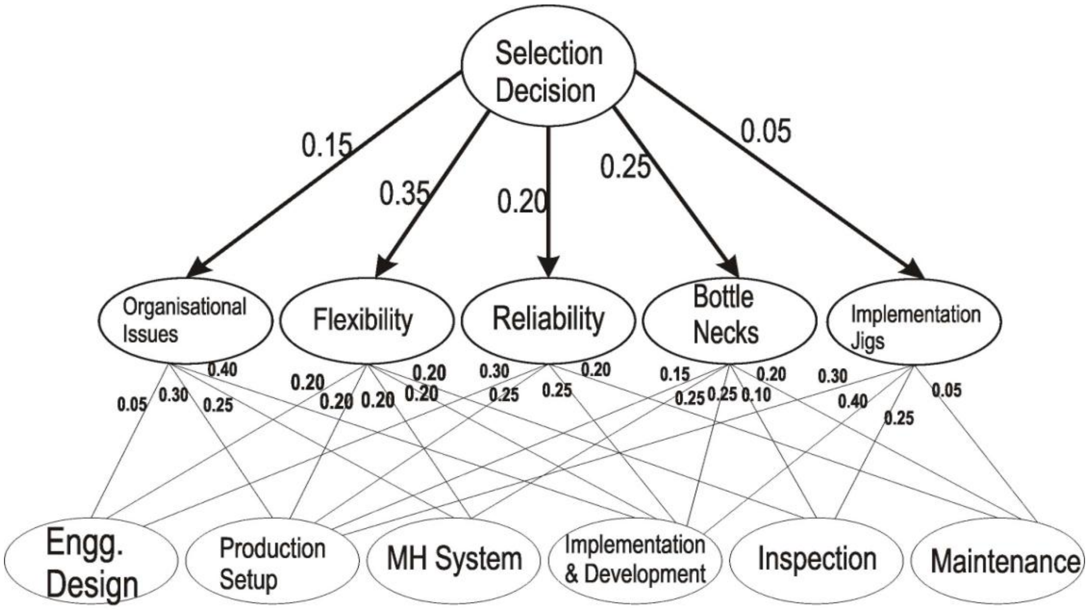

Figure 2: AHP analysis for alternative layouts

The numbers underneath in the figure indicate the relative importance of each activity and will be used in cost – effect model. This is the first step of our analysis. Next is the allocation of cost for each of the FLs. The table 4 shows the ABC cost allocation for alternative facilities layouts.

Table 4: ABC allocation

Cost components (in Hundred Thousand Dollars)

Alternative FLs	Engg. Design Cost	Prodn. Setup Cost	M H Cost	Improvement and Development Cost	Inspection Cost	Maintenance Cost	Total
FL_1	0.15	50	0.1085	0.148	0.036	0.35	50.7925
FL_2	0.10	75	0.063	0.0925	0.046	0.25	75.5515
FL_3	0.0225	145	0.021	0.037	0.08	0.3125	145.473
FL_4	0.125	95	0.084	0.185	0.04	0.275	95.709
FL_5	0.25	155	0.0508	0.074	0.032	0.2375	155.6443

Once the priority weights are obtained, the cost-effect model gives more a clear picture. This is the second step in our FL analysis. Combining the above steps, the cost impact model is generated. It is shown in the figure 3. The numbers underneath in the figure 3 represent the alternative weighting scores. The score is obtained by first multiplying the relative importance of each activity by the ABC cost allocation for each alternative obtained from tables 2 and 3 and then summing up the results for each alternative FLs. Thus the scores obtained for alternatives are listed below in the table 5.

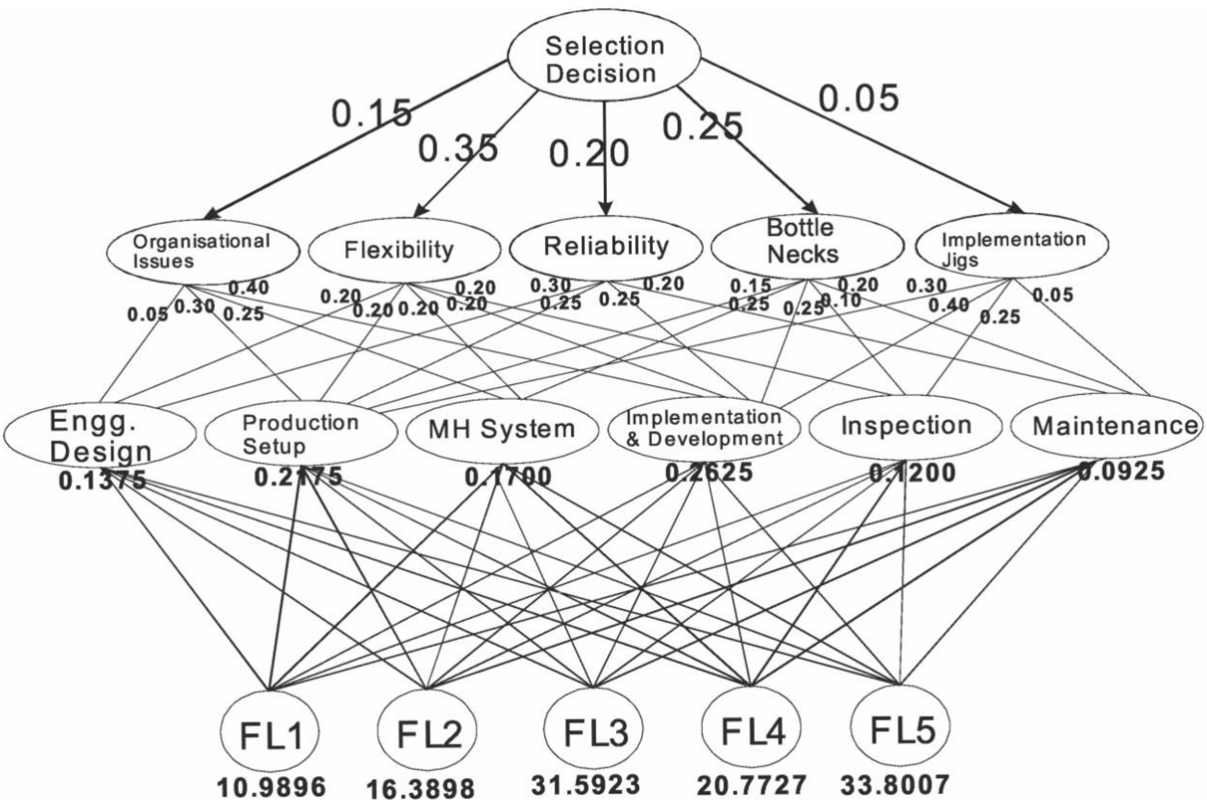

Figure 3: Cost-effect model comprising alternative layouts

Table 5: Overall Weighting Scores

Facilities Layouts	Overall weighting scores
FL_1	10.9896
FL_2	16.3898
FL_3	31.5923
FL_4	20.7727
FL_5	**33.8007**

VII. Discussion & Conclusion

In order to remain competitive in the future, firms must make the decision regarding selection of facilities layouts based on strategic goals contrary to traditional investment analysis, the investments that best support these goals may not always be those with highest financial returns. Thus by incorporating the activities and strategic goals into investment analysis, the managements can take a better decision.

The example used in this paper compares investments on five alternative layouts. The underlying assumption is that the management has decided to make a capital investment and that each of the alternatives is within the management's budget. The model then provides a frame work for ranking the alternatives. Note that the model could just as easily accomodate many more alternatives, as long as each of those are within the budget.

In developing the cost model, the effect of depreciation on overheads was not included. Instead, the equivalent annual cost of the initial investment was used because as long as we are comparing alternative investment opportunities, this method works well, since it considers the time value of money. The cost model thus developed, tends to favour the new technology (FL_5), forcing the decision makers to consider the relative merits of non-financial as well as financial criteria.

VIII. Summary

The decision model presented in this paper favours the alternative FL_5 even though the net cost savings could be higher for other alternatives, because of the higher weighting score for FL_5. The present algorithm allows investments to be evaluated on their merits to the company as a whole and not just to individual departments or products. This is done by focusing on activities and how they support strategic goals. We combine AHP techniques with ABC concepts to develop a cost impact model. Finally, the alternative layout with the highest score is selected.

References

[1]. Andijani.A , Production Planning & Control, 1998,Vol.9, No.2, 121-126, Setup Cost reduction in a multi-stage order quantity model.
[2]. Aseiedu Y, Besant, R.W., Gu.P, 2000, Simulation based cost estimation under economic uncertainty using kernel estimatiors., IJPR 38(9), 2023-2035.
[3]. Borden, J.P., 1990, Review of literature activity-based costing, Journal of Cost Management for the Manufacturing Industry, 4,5 – 12.
[4]. Brimson, J.B., 1989, Activity-Based Investment Management, New york, American Management Association.
[5]. Canada, J.R. and Sullivan, G.W., 1989, Economic and Multiattribute Evaluation of Advanced Manufacturing Systems (Englewood Cliffs, NJ : Prentice-Hall).
[6]. Chan, I.Y. and Lynn, B.E., 1993, Hierarchical analysis as a means of evaluating tangibles and intangibles of capital investments. The Mid-Atlantic Journal of Business, 29, March, 59-74.
[7]. Clark, J.J., Hindelang, T.J and Pritchard, R.E., 1979, Capital Budgeting, Planning and Control of Capital Expenditures (Englewood Cliffs, N J : Prentice-Hall).
[8]. Cooper, R. And Kaplan, R.S., 1988, Measure costs right make the right decisions, Harward Business Review, September – October, 96 – 105.
[9]. Cooper, R., Kaplan, R.S., Maisel, L.S., Morrissey, E and Oehm, R.M., 1992, From ABC to ABM, Management Accounting, 74, November, 54 – 57.
[10]. Cooper R. And Kaplan R.S., 1989, How Cost Accounting Distorts Product Costs, Management Accounting, 69, April, 20 – 27.
[11]. Cooper, R., 1989, The rise of activity-based costing - - IV, What do activity-based cot systems look like ? Journal of Cost Management, Spring, 38 – 49.
[12]. David Ben-Arieh, Li Qian, Int.J.Production Economics, 2003, Activity Based cost management for design and development stage, 83, 169-183.
[13]. Donald S.Remer, Harry R.Buchanan, Int.J.Production Economics, 66, 2000, 101-104, Estimating the cost for doing a cost estimate.
[14]. Dunbing Tang, Walter Evershim and Gunther Schuh, Qualitative and Qauntitative cost analysis for sheet metal stamping, Int.J.Computer integrated Manufacturing, July-August 2004, 17(5), 394-412.
[15]. Harker, R.S., 1988, The Art and Science of Decision Making : The Analytical Hierarchy Process, Decision Sciences Working Paper, 88-06-03, Decision Sciences Department, The Warton School, University of Pennsylvania, Philadelphia, PA.
[16]. Hodby T., Thomson J., Sharman P., 1994, AB management at AT & T, Management Acounting 75(10), 35-39.
[17]. Kaplan, R.S., 1992, In defense of activity-based cost management, Management Accounting, 74, November, 58 – 63.
[18]. Lewis R.J., 1995, AB models for Cost management Systems, Quoram Books, Westport, CT.
[19]. Luong, L.H.S., Spedding, 1995, An Integrated System for process planning and cost estimation in hole making, Int.J. of Advanced manufacturing Technology,10, 411-415.
[20]. Maria A.P and Aurora.Z, 1994, Int.J.Production Economics, 34, 83-89, Investment and production cost analysis in food processing plants.
[21]. Merz C.M., Hardy A., 1993, ABC puts accountants on design team at HP, Management Accounting 75(3), 22-27.
[22]. Miller S.H., 1994, The view from inside GM's general auditor looks back, Journal of Accountancy, 177(3), 44-46.
[23]. Park C.C., Kim G.T., 1995, An economic evaluation model for advanced manufacturing system using ABC,Journal of Manufacturing Systems 14(6), 439-451.
[24]. Reeve, J.M., 1989, Variation and the cost of activities for investment justification, Proceedings of the IIE Integrated Systems Conference and Society for Integrated Manufacturing Conference, pp. 593 – 598.
[25]. Saaty, T.L., 1980, The Analytic Hierarchy of Process, (New York, McGraw–Hill)
[26]. Sawhney, R.S., 1991, An Activity-based Approach for Evaluating Strategic Investments in Manufacturing Companies, Journal of Manufacturing Systems, 10(5), 353 – 367.
[27]. Soloway L.J., 1993, Using AB management systems in aerospace and defence companies, Journal of Cost Management 6(4), 56-66.
[28]. Takakuwa.S, 1997, The use of simulation in ABC for FMS. Proceedings of the 1997 winter simulation conference, December7-10,Atlanta, GA,USA, pp,793-800
[29]. Takeo Yoshikawa, John Innes & Falconer Mitchell, Int.J.Production Economics, 1994, Applying functional cost analysis in a manufcturing environment, 36,53-64.
[30]. Tsai W.H., 1996, ABC model for joint products, Computer & Industrial Engineering 31(3/4), 725-729.
[31]. Turney, P.B.N. and Stratton, A.J., 1992, Using ABC to Support Continuous Improvement, Management Accounting, 74, September, 46 – 50.

International Journal of Engineering Science Invention (IJESI) is UGC approved Journal with Sl. No. 3822, Journal no. 43302.

APA MLA Chicago G. Shashikumar . "Evaluation of Facilities Layout alternatives by integrating concepts of ABC & AHP." International Journal of Engineering Science Invention (IJESI) 6.7 (2017): 20-25.