AN EXPERT SYSTEM FOR MAKE OR BUY DECISION IN MANUFACTURING INDUSTRY

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ABSTRACT

A computer-based system is designed to assist manufacturing industries in the make or buy decision, which is arguably the most fundamental component of manufacturing strategy. A model of make or buy decision was developed through review of literature and discussion with industry people. The system employs both case-based reasoning (CBR) and decision support system components. As part of the development process, interviews were conducted with managers in valve manufacturing industry in order to determine current make or buy practice and elicit opinions on how the decision-making process would be enhanced. The model consists of various checks as technology, capacity, sorting of parts by cost in descending and allocating capacity for parts which give maximum cost saving as first. A Knowledge Based System (KBS) was developed which incorporates these checks into the make buy decision. This system is used for analysis of capacity of machine used and idle capacity remaining for better performance of the industry. Expert system developed is also used to take decision about a new part /product to be manufactured inhouse or bought outside and save the time in decision making.

Key words: Make Buy Decision, Expert System, Cost, Capacity and Technology

1. INTRODUCTION
Nowadays, complexities in the business atmosphere, an increase in the competition between manufactures, shortage of resources, and lots of other factors have caused manufacturing industries to move toward making use of optimum processes and decisions in order to get permanence.

There is continuous pressure to drive down costs and increase quality of the product. From the industrial revolution to early 1980s, manufacturer's strategy was based on establishing processes and requirements related to the production of all the parts in a product or ordered ones within industry. This was relied on the available resources and workforce; however, in facing lots of difficulties, so many industries have moved toward focus on core activities-house and outsource non-core activities. In fact, outsourcing is handing over some of the primary or non-primary activities of the industry which are carried out based on decision making processes; therefore some of these results will be acquired using outsourcing and some others insourcing. This causes a decrease in the system's vertical integration rate. In general, outsourcing is used to decline production costs, access to a higher technology and skill, efficiently use of the available time and limited resources on the industry.

Intelligent real-time decision support systems are specialized domain-based tools for management. The intelligent component of decision support systems (DSS) assumes a certain level of human expertise that can be used to advise the manager on certain decision issues. In the domain of make buy decision for a part to be manufacture in-house or buy, emphasis has been on decision about part to be make or buy. In the manufacturing industries, the problem of taking a right decision about part to be make or buy for their better performance.

The rest of this paper is organized as follows. In Section 2, literature review, and in Section 3 Design of expert system for making Make-Buy decisions are described. In Section 4, evaluation and In Section 5 the conclusion is given.

2. LITERATURE REVIEW
Probert [6] presented a strategic methodology for production or purchasing decisions which was based on a thorough analysis of all the different aspects of production technologies. McIvor et al [3] tried to explain a conceptual framework for production or purchase of strategic goods by emphasizing the establishment of a sharing relationship with the chosen supplier. One of the applications of this framework is for the organizations in which so much strategic attention should be paid to decision-making in production or purchase. Padilo and Dibey [5] for the first time looked at this issue using a multitude of criteria. They presented a methodology for analyzing decision making in seven stages to evaluate the strategies of production or purchase. Aktan et al [1] developed a financial model for evaluating the value of outsourcing options. In fact, this model provides a comprehensive framework for evaluating the whole expected costs of outsourcing from a network of suppliers when the purchase is faced with unknown exchange rate. Monte Carlo simulation method has been used for the evaluation. Tills and Dreary [7] developed a model which supports decision making related to purchase or production based on an investigation of the goods and investment's being strategic.

Momme, J., Hvolbyb, H. H. [4] developed a systematic framework for strategic outsourcing. This framework, with the help of internal management tools and external marketing tools, links 6 basic levels of outsourcing to strategic programming of the organization and helps the reciprocal linkages between the functions of the process of
outsourcing to be known. Humphreys et al [2] used sophisticated systems based on KBS to design the model for evaluation of decisions made about purchase or production. This model is comprised of 5 major levels: identifying and weighing performance-related criteria, analyzing technical abilities, comparing internal and external capacities, analyzing the capabilities of the supplying organization, and analyzing the whole cost of ownership. KBS has linked all these 5 stages. Water and Pate [9] proposed a model of outsourcing decision-making which has more strategic focus and has a structure which makes it possible to use a technique in order to decrease the complexity of the process. Yousefi Nejad Attari et al [10] proposed a new hybrid multi-criteria model for decision-making. They have attempted to make decisions about outsourcing and insourcing related to productive activities in the occasions when there is no absoluteness based on a variety of qualitative and quantitative criteria. This model which is based on the combination of ANP and DEMATEL methods in fuzzy environment can take decision about make buy.

A comprehensive study of the related articles on this issue shows that by the passing the time, researchers have reached this conclusion that costs is not sufficient in making decisions about outsourcing or insourcing and other criteria must also be taken into account. However, developing an expert system for making decisions about insourcing or outsourcing of a part in less time is a challenging task. An attempt is made by author to develop an expert system for make buy decision in this paper.

3. DESIGN OF EXPERT SYSTEM FOR MAKE-BUY DECISION MAKING

Expert system is a computer system that emulates the decision making ability of human expert. Expert systems are designed to solve complex problems by reasoning about knowledge, represented primarily as if-then rules rather than through conventional procedural code [8].

3.1. The problem

Make-or-buy decision is a judgment made by management whether to make a component internally or buy it from the market. Make or buy decision is always a valid concept in business. No organization should attempt to make something by their own, when they stand the opportunity to buy the same for much less price.

Following constraints have been used while making make or buy decision

- The volume
- The fixed cost of making
- Per-unit direct cost when making
- Per-unit cost when buying

3.2. The Solution:

A Decision Support System (DSS) is developed to provide solution to the Make-or-buy decision making problem.

Components of a DSS –

- Knowledge Management Component
- Data management Component
- Model Management Component
- User Interface Management Component
3.3. Knowledge Management Component
The knowledge management component, like that in an expert system, provides information about the relationship among data that is too complex for a database to represent. It consists of rules that can constrain possible solutions as well as alternative solutions and methods for evaluating them. Figure 1 shows flow chart for make buy decision. The item is input to the system. The system checks for technology available inhouse. If it is not available, the item is to be outsourced. If it is available, the system checks for capacity available to process the item. If it is not available, the item is to outsourced. If it is available, a list of items that can be manufactured inhouse is prepared such that the complete batch of items can be manufactured inhouse. The items are arranged in descending order of cost savings between bought out cost and inhouse manufacturing cost. Capacity of the machine is allocated by giving maximum cost saving item first. When the inhouse capacity is exhausted, the remaining items in the list obtained after capacity check are outsourced. Finally, the system gives the make list and outsourcing list of the items.

3.4. Flowchart

![Flowchart for make buy decision.](image)

3.5. Data management Component
A database or data warehouse that holds and maintains data for the DSS. For the proposed solution data is stored in Microsoft SQL Server database.

3.6. Model Management Component
A model is a representation of some event, fact, or situation. As it is not always practical, or wise, to experiment with reality, people build models and use them for experimentation. Models can take various forms.
Various real life entities involved in Make-or-Buy decision are modeled as database tables in the solution developed as follows for deciding whether an Item to be manufactured or to be bought.

**Table Name: Master_Item**

Table 1 stores data related to items, such as item number, item description and whether the item is a 100% Make, 100% buy or is to be considered for make-buy decision process.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description of data stored</th>
</tr>
</thead>
<tbody>
<tr>
<td>PK_ItemID</td>
<td>Primary key to uniquely identify the Item</td>
</tr>
<tr>
<td>Item_No</td>
<td>Item number</td>
</tr>
<tr>
<td>Item_Desc</td>
<td>Item Description</td>
</tr>
<tr>
<td>Parent_Item</td>
<td>Item no of the parent item.</td>
</tr>
<tr>
<td>MBCategory</td>
<td>Indicates whether the item is a 100% Make, 100% buy or is to be considered for make-buy decision process.</td>
</tr>
</tbody>
</table>

Various costs of the Item, table Master_Item_Cost is used with reference from Master_Item table

**Table Name: Master_Item_Cost**

Table 2 stores Item cost information such as inhouse and bought-out cost for each item. Master_Item_Cost table is related to Master_Item table by the foreign key FK_ItemID.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description of data stored</th>
</tr>
</thead>
<tbody>
<tr>
<td>FK_ItemID</td>
<td>Foreign key reference to Master_Item</td>
</tr>
<tr>
<td>Item_Cost_Inhouse</td>
<td>Cost of the item if item is manufactured inhouse.</td>
</tr>
<tr>
<td>Item_Cost_Buy</td>
<td>Cost of the item if item is bought from market</td>
</tr>
</tbody>
</table>

Technologies used to manufacture the item.

**Table Name: Master_Technology**

Table 3 stores data related to technologies whether available inhouse or not.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Description of data stored</th>
</tr>
</thead>
<tbody>
<tr>
<td>PK_Technology_ID</td>
<td>Primary key to uniquely identify the Technology</td>
</tr>
<tr>
<td>Technology_Name</td>
<td>Name of the technology</td>
</tr>
<tr>
<td>IsInhouse</td>
<td>Flag to indicate whether the technology is available inhouse or not.</td>
</tr>
</tbody>
</table>

Machines used to manufacture the item inhouse.

**Table Name: Master_Machine**

Table 4 stores information about name of the machine and it’s capacity in minutes.
3.7. User Interface Management Component

The user interface management component allows user to communicate with the Decision Support System. This is the component that allows user to combine his/her know-how with the storage and processing capabilities of the computer. The user interface is the part of the system .The user sees through it when entering information, commands, and models. This is the only component of the system with which user have direct contract.

The Software will open the login screen where in the user has to enter the user name and password for authentication as shown in Figure 2.

After login, the name of the various screens will be displayed. The various screens are –

1. Item Master Screen
2. Technology Master Screen
3. Machine Master Screen
4. Machine Routing Group
5. Make-Buy Decision Making Screen (Evaluation Screen)

The user can select the required screen for his work.
**Item Master Screen** The user will enter the following details

- Item number
- Item Description
- Make/Buy category – whether the item is 100% make, 100% buy or is to be consider for make-buy decision process

Next, the user will enter the following item cost details –

- Cost of the item if the item is manufacture inhouse
- The cost of item if item is brought from market

Then, the user will select the technology and enter the machine routine details for the Part of the product to be manufacture. On closing the screen the data entered will be stored in the respective table in SQL database. The screen shot of Item_Master is shown in Figure 3.

![Figure 3 The screen shot of Item_Master](image)

**3.8. Technology Master Screen**

The user enters the technologies required to manufacture the parts of the products, indicating its in-house availability or not.

On closing the screen the data entered will be stored in master technology table. Figure 4 software screen of Technology_Master.

![Figure 4 Screen of Technology_Master](image)

**3.9. Machine Master Screen**

The user enters the machines along with their available capacity required to manufacture the parts of the product. On closing the screen the data entered will be stored in master machine table. The screen of Machine_Master is shown in Figure 5.
3.10. Machine Routing Group
The user will enter the part name and the machines required to process that part along with the machining time and set up time. On closing the screen the data entered will be stored in machine routing details table.

4. EVALUATION
The system prototype developed has been refined and tested for valve manufacturing industry. Preliminary work was focused on customizing the generic model of the make or buy decision process. The system currently proficient at finding number of parts in a product to be manufacture in-house or outsource based on technology, capacity, cost and quality (rejection)criteria. This system assists in giving correct decision about part to be manufacture in-house or outsource in less time. Figure 7 shows evaluation screen for make buy decision of the software.

4.1 Make-Buy Decision Making Screen (Evaluation Screen)
The steps to be followed are as follows:
1. The user clicks on perform make/buy decision.
2. Then if the user clicks on 100% buy items, the system gives the list of items that are to be 100% brought out.
3. If the user clicks on technology check, the system gives the list of parts to be given outside for manufacturing due to lack of technology.
4. If the user clicks on capacity check, the system gives the list of parts to be given outside due to insufficient capacity.

5. If the user clicks on Inhouse make items, the system gives the list of parts that can be manufactured in-house due to available technology and sufficient capacity. The items are categorized into – 100% make followed by make or buy with in each category, the items are displayed in descending order of cost saving.

6. If the user clicks on buy out items, the system gives the list of items to be bought because of more in-house cost and because the capacity is occupied by other parts (the parts in 100% make category and MB category).

7. When the user clicks on machine item allocation, the system gives the list of parts along with machining time of each machine required for each part as well as the idle time of each machine after all the machine allocation is done.

8. When the user clicks on export to excel (Decision), the system exports the decision file to excel.

![Figure 7 Make buy decision making screen.](image_url)

5. CONCLUSION

This system helps the user in taking decision about making the parts of product 100% in-house, buying 100% outside or making some parts in-house and buying some parts form outside(make buy category). This is done by applying various checks – technology, capacity and cost. This system saves the time for decision making about the part in the product. This system also gives the total cost of the product. In addition to valve manufacturing industry, this software can also be useful to other industries incorporating their technology and capacity for manufacturing.

REFERENCES


An Expert System For Make or buy Decision In Manufacturing Industry


