1989-03-01

The Use of Expert Systems in Demand Forecasting

Edward Sweeney
Technological University Dublin, edward.sweeney@tudublin.ie

Sunderland Advanced Manufacturing Technology Conference 1989 (SAMT 89)

THE USE OF EXPERT SYSTEMS IN DEMAND FORECASTING

E. T. Sweeney

1. Introduction

Accurate forecasting of product demand is essential if the management of a manufacturing system is to be as effective as possible. In virtually every production planning decision some kind of forecast needs to be considered. In recent years the greater uncertainty in economic and financial affairs, caused in part by the rapid rate of technological development, has sharpened the focus on the need for improved forecasting. An expert system is a computer system which possesses a set of facts, heuristics or knowledge about specific domain of human expertise, and by manipulating these facts intelligently it is able to make useful inferences for the user of the system. These systems make use of rules of inference to draw conclusions or make decisions within defined areas. Their power comes from the presence of facts and procedures which have been identified by human experts as the key components in the problem solving process. In recent years, developments in computer hardware and software have facilitated the use of expert systems in industry. The aim is to explore the potential usefulness of such systems in forecasting.

2. Expert systems in demand forecasting

A large number of both qualitative and quantitative forecasting techniques are currently available. By using computers, quantitative techniques (time series and causal models) which involve much calculation and processing and incorporate a wide range of variables can be run off accurately and in a short time. Access to relevant databases has also been simplified, and the effect of variations in data considered sensitive to change can easily be explored. However, each forecasting technique has its special use and care must be taken to select the correct technique for a particular application. A large number of complex factors must be considered in the selection of an appropriate technique. The application of knowledge-based systems could, therefore, be of great benefit. Such a system would involve the embodiment within a computer of the knowledge needed in deciding which technique to use.

3. Knowledge acquisition

3.1 Introduction

The knowledge acquisition phase involved the gathering of facts and heuristics concerning the factors which influence the decision concerning which forecasting technique used. This knowledge came mainly from the author’s experience of implementing demand forecasting technique strategies, but a number of colleagues and published works (primarily Chambers *et* al., 1971; Makrifakis *et* al., 1979; Levenbach *et* al., 1982) were consulted on some of the more subtle and difficult points. So, far the most part, the author performed the role of both the forecasting expert and the knowledge engineer. The assuming of both functions did not in any way detract from the knowledge acquisition process; indeed it reduced the time needed and helped ensure that problems which are frequently encountered at this stage (Kidd, 1987) were largely avoided.

3.2 Techniques considered

Sixteen commonly used forecasting techniques were considered (see Table 1). It was seen as important that knowledge about a range of both qualitative and quantitative methods be embodied in the expert system in order to ensure widespread applicability. With regard to quantitative techniques both time series and causal models were investigated. It can be seen from Table 1 that the methods considered varied from the very simple (e.g. using the demand figure for the previous period) to the quite complex (e.g. econometric modeling).

3.3 Factors influencing choice of technique

Many complex and often inter-related factors need to be considered in choosing an appropriate forecasting strategy. Table 2 outlines the general classification of those factors considered in this study, as well as describing in more detail what is meant by each one.

Table 1: Forecasting techniques considered in the study

Type of technique	**Technique**
Qualitative	The Delphi method
	Market Research
	Panel consensus
	Visionary forecast
	Historical analogy
Time series	Past average
	Figure for last period
	Moving average
	Exponential smoothing
	Box-jenkins
	X-11
	Trend projection
Causal	Regression
	Econometric model
	Input- output model
	Life cycle analysis

3.4 Choice of technique

Once the factors influencing the choice of technique have been identified, the situations in which a particular technique is appropriate need to be established. The nature of any situation can be assessed by examining the status of the relevant influencing factors (see Table 2).

To achieve this, each of the 16 techniques under consideration (Table 1) was examined in turn. Each was examines in terms of influencing factors with a view to establishing its appropriateness in a range of situations. For example, for the visionary forecasting technique the knowledge acquisition process would arrive at a statement such as the following:

“A visionary forecast is usually poor in terms of its accuracy and turning point identification, is easy to understand, takes only days to arrive at, gives a long term forecast (over two years), is inexpensive to implement and requires little, if any tabulated data,”

A statement in similar form was arrived at for each of the 16 techniques. These statements must be transformed into a format which allows for their embodiment in a computer.

Table 2: Factors influencing choice of forecasting techniques

Factor	**Explanation**
Accuracy of forecast	Is accuracy considered to be of
	importance
Turning point	Is the identification of turning points
identification	considered to be of importance?
Ease of understanding	Is ease of understanding of the
	forecasting methodology and
	interpretation of the forecast
	considered to be of importance?
Time span	What is the time span of the forecast?
	Immediate term (hours)
	Short term (days)
	Long term (months)
Time horizon	What is the time horizon of the
	forecasting?
	Short range (0-3 months)
	Medium range (3 months-2 years)
	Long range (over 2 years)
Cost of forecast	What financial resources are available
	in making the forecast?
Availability of data	What relevant data are available?
	Demand patterns for previous
	periods
	Market research reports
	Factors influencing demand
	patterns
	Similar product information
	In-company product and service
	flows
Data characteristics	What characteristics are apparent in
	existing data?
	Secular trends
	Seasonal variations
	Cyclical variations
	Irregularities

4. Knowledge representation

A number of knowledge representation schemes were evaluated in view of the nature and format of the acquired knowledge. These included production rules, frame-based representation and semantic nets (Forsyth, 1984). It was decided to use production rules primarily because the knowledge could be easily and accurately represented in this form. The knowledge was, therefore, rewritten in terms of antecedent- consequent (IF..THEN) rules. The rule for the visionary forecasting technique presented above would then be expressed as follows:

IF accuracy is not of importance
AND turning point identification is not of importance
AND ease of understanding is not of importance
AND time span is short term
AND time horizon is long term
AND available resources are very limited
THEN the use of visionary forecast appears to be appropriate.

No reference is made in the above statement to availability or characteristics of data. This is to ensure that, although in the making of a visionary forecast tabulated data is not generally used, the existence of such data should not preclude its use. Care was taken to ensure that points of this nature were recognized in forming the production rules from the acquired knowledge for all the techniques inder consideration.

5 Software development tools

5.1 Expert system shells

An idea which is appealed to many as an aid to developing working expert systems is to make use of a standard framework or shell, and a large number of commercially available shells have become widely used in the last few years (Bramer, 1985). Such a shell can be thought of as a full expert system with its knowledge base taken away.

i.e. EXPERT SYSTEM – KNOWLEDGE BASE = SHELL

thus providing the developer with an ideal framework for the construction of a knowledge base in a given field. Shells provide a carefully co-ordinated collection of tools supporting a variety of knowledge representation and reasoning schemes. A typical shell would include the following (Ranlefs, 1984):

Interpreters and/or compliers of knowledge representation techniques; inference support; knowledge base management system tools for explaining rationales or justifications of courses of action; tools to support acquisition and modification of knowledge; tools for external interfaces (e.g. displays).

Their provision of facilities such as those outlines above can greatly reduce the development time of an expert system. Thus, the increasing availability of such shells is likely to result in more widespread acceptance and use of expert systems. The way in which the forecasting knowledge described above is represented lends itself readily to embodiment using a shell which employs antecedent-consequent rules.

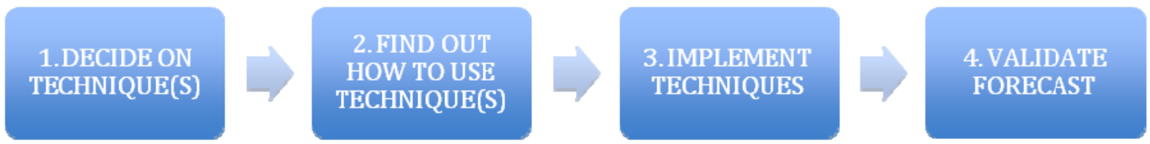
5.2 Crystal
Crystal is a general purpose expert system shell that can be used on personal computers. It uses production rules in the building of a knowledge base. Starting with a single line description of what the application is seeking to achieve (e.g. ‘an appropriate forecasting technique can be recommended’), Crystal allows indefinite expansion of that thought. Each step is a sequence of logical alternatives. The forecasting production rules outlined above were implemented using Crystal. The system (FOREX) is described below.

6. System description (FOREX)

6.1 Recommendation of techniques
The decision concerning which forecasting technique to use is based on the contents of FOREX knowledge base and responses given be the user to system prompts concerning the status of the relevant factors outlined in Table 2. At the end of the consultation FOREX will recommend one or more techniques and, if required, give an explanation as how it has reached its decision. Information concerning typical application areas is also displayed. This, and the explanation facility, help improve credibility of the expert system’s decision making process in the user’s mind. Alternatively is no technique appears to be suitable an appropriate message is displayed. Expert system approaches are increasingly being used in the development of computer assisting learning (CAL) systems (Lewis et al., 1987). Expert system shells often provide an ideal framework for the development of CAL coursewares. As well as recommending a forecasting technique FOREX can explain what implementing the technique involves, state the underlying theoretical basis and give references if additional information is required. This information is presented both as a page of text and, where appropriate, graphically.

7. Further work

The decision about which forecasting technique(s) to use can be considered to be the first stage in arriving at an actual forecast (see Figure 1). Stage 1 of this process can be carried out using FOREX, as already described. Stage 2 can be achieved, albeit to somewhat limited extent, using CAL aspect of FOREX, described above. Work is currently being undertaken at improving this aspect of FOREX and involves study of various computer based pedagogical approaches as well as the utilization of advanced features of CRYSTAL such as interfacing with specially written routes (in, for example, C).



Integration of FOREX with existing commercially available forecasting software would provide a more complete and comprehensive framework in which to develop an accurate forecast. Work being carried out at present aims to integrate FOREX with a number of commercially available software packages as well as with appropriate databases.

8. Conclusion

Traditionally, computerized forecasting has involved the development of a forecast using one of the quantitative techniques discussed in this chapter. By using computers, calculations and processing which often incorporate a wide range of variables can be run off accurately and in a short time. The effects of any amendments can also be explored by changing variable data. The application of expert systems provides a framework in which the knowledge required to select an appropriate technique can be embodied. In addition, it can provide a facility for the production of “intelligent” teaching systems. By providing access to the knowledge needed in selecting the forecasting technique most appropriate to a particular set of circumstances, the use of the expert system strategies outlines in this chapter could have a major impact on the nature of the forecasting process, in relation to product demand as well as other factors, within manufacturing industry.