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RETROSPECTIVE VALUE ANALYSIS OF DECISION SUPPORT BENEFITS FROM A PRODUCTION PLANNING SYSTEM FOR A BREWERY

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ABSTRACT

A decision support system for production planning in a brewing company was developed to assist with the planning of brewing, packaging and distribution of beer and to minimize production costs. Having been in operation for some time, the system has changed and adapted in a very dynamic environment. The system's present form and current use are discussed. Initial management approval for system development was based on faith rather than proper cost–benefit and value analyses. This paper aims at retrospectively highlighting these values and benefits with regard to supporting decision–making in the company.

Keywords: Decision Support, Production Planning, Value Analyses, Cost Benefit

1. INTRODUCTION

Decision support systems (DSS) are concerned with the use of computers to aid decision–making. These interactive systems are designed specifically to improve the effectiveness and productivity of managers and decision–makers. The aim is to assist and to support rather than to replace decision–makers' judgement. This is achieved by not automating the decision process and by not imposing any sequences of analysis onto the user. Furthermore, decision support systems are typified by the fact that they are flexible and adaptable. Therefore, they constantly grow and evolve as the demands of the situation and environment change.

Since the inception of decision support systems during the early seventies many such systems have been developed, while research into various aspects of these systems has proliferated. A number of studies have been performed to characterize what constitutes these systems, giving rise to a proper framework and foundation for decision support systems. An aspect of decision support systems that is to a large extent still unresolved is the question of DSS benefits and the basis on which managers can justify the approval of such systems. DSS benefits are most often seen as intangible and non–quantifiable, and are therefore usually expressed in descriptive terms. The nature of decision support systems is such that it is very difficult to place a value on these benefits and to determine the costs involved in developing them. A DSS is something that grows and evolves in response to users' experience and learning. There is thus no "final" system.

This paper is aimed at retrospectively highlighting the benefits and values of a specific decision support system, namely a production planning system (PPS) developed for a very large brewing company in South Africa. As far as the author is aware, this was one of the first such systems in South Africa, and as is the case with many documented decision support systems, management approval for system development was to a very large extent based on faith rather than proper cost–benefit and value analysis. Today, five years after development on the system was started, PPS is an integral part of the beer production planning process. Through discussions with current management and users of the system it was possible to obtain feedback on the use of the system since its implementation and on the benefits and values of the system to the company. An attempt was made to quantify these values and benefits but as in many similar decision support systems it proved to be very difficult and almost impossible.

The paper is organized as follows. A brief review of current literature on this issue is given in Section 2. The problem for which PPS was developed is briefly described in Section 3, while an outline of PPS itself is given in Section 4 – the system is extensively documented in Currin and Ittmann (1984a, 1984b, 1984c and 1985) and Ittmann (1985). This brief outline and description of the system is given for the sake of completeness. A description of the present PPS and its use is given in Section 5, while the value and benefits of PPS are described in Section 6.

2. SURVEY OF EVALUATION APPROACHES

Managers face a dilemma in assessing and evaluating DSS development proposals. Traditional methods, such as cost–benefit analysis, are not well suited to evaluate such systems, primarily because of the difficulties in defining, quantifying and measuring the often qualitative and intangible benefits. "How can one assign a monetary value to effectiveness–oriented benefits ...?" or "What is the dollar value of facilitating interpersonal communication or expediting and improving problem–solving activities?" These (Alter (1980)) are typical questions when a DSS must be evaluated or justified. In many cases there is no convincing way of "proving" that money was saved. "Benefits are especially hard to assess since they depend largely on the decision–maker's perception" (Hurst, et al., 1983).

Keen (1981) lists a number of DSS benefits that have been frequently cited in DSS case studies. These include: an increase in the number of alternatives examined, a better understanding of the business, fast response to unexpected situations, the ability to carry out ad hoc analysis, new insights and learning, improved communication, control, cost savings, better decisions, more effective teamwork, time savings, and better use of data resources. It seems therefore that the decision to build a DSS is not based on cost but rather on the perceived value and usefulness of the system.

To justify developing a DSS, Keen proposes a value analysis approach that firstly emphasizes the value of a system rather than the cost. Secondly, uncertainty and risk are reduced by insisting that prototyping be part of the evaluation method, and thirdly, the DSS should be seen as innovative and should be treated as a research and development effort.

Sprague and Carlson (1982) suggest four possible measures that can be used in evaluating the impact of DSS. These are

(i) productivity measures to evaluate the impact of DSS on decisions;

(ii) process measures to evaluate the impact of DSS on decision–making;

(iii) perception measures to evaluate the impact of DSS on decision– makers; and

(iv) product measures to evaluate the technical merit of the DSS.

Most of the measures are qualitative and will depend on individual judgement. The product measures do, however, include quantitative measures such as development, operating, maintenance, education and data acquisition costs, which could help quantify the value of a DSS.

Money and Wegner (1986) propose a quantification approach that is intended to give substance to the value analysis framework of Keen (1981). Through identification of suitable DSS benefits, their method, called the conjoint measurement method focuses on quantifying the intangible benefits normally associated with a DSS. Although the emphasis is still on value rather than cost, this approach provides a means of converting subjective judgements about the relative importance of intangible benefits into numeric scores. Using this approach, it is possible to obtain guidance on whether development of a DSS can proceed or should be stopped. Money and Wegner illustrate their method via a specific DSS application in the area of compensation planning. This method goes a long way towards quantifying DSS values and benefits, however, it appears to be a very involved and laborious approach – its implementation could be time–consuming

The problem of evaluating and quantifying the benefit of a DSS has, as shown above, received some attention in the literature. There does not appear to be an easy–to–use procedure or method to define, measure or quantify the values and benefits of such systems. This is mainly due to the fact that many of the real benefits are qualitative and intangible. Money and Wegner's approach does go some way towards trying to quantifying these intangible efforts but it is a rather cumbersome approach. It therefore seems that in many instances approval by management to build a DSS would still be an act of faith.

3. PROBLEM DESCRIPTION

Almost all clear beer in South Africa is produced by the South African Breweries Limited (SAB). For ease of production, logistical and capacity planning, the Beer Division divides the country into a number of regions, each being responsible for the beer requirements in its own region. Annual and quarterly production plans, based on sales forecasts, are needed. These are produced at a weekly level of detail for the brewing, packaging and distribution of beer.

In the largest of these regions there are six breweries, each with brewing and packaging facilities. Seven different brands of beer are marketed and sold in eight different packs or containers. No brewery can produce the full brand/pack range, although not all brands are packaged in the full pack range. The beer is brewed and packaged at the breweries before it is distributed to some fifteen depots from where it is in turn sold to retail outlets. Every year a budget plan is developed for the forthcoming year. This plan is revised quarterly while contingency plans are also developed to cater for unexpected situations, such as very high or very low sales volumes or labour strikes.

A production plan consists of a brewing, packaging and distribution plan. Brewing, although it precedes packaging, is dependent on the sales forecast and the packaging plan. It is important for the appropriate brands to be available at the right times and at the right breweries for packaging when required. Furthermore, provision must be made for the ageing or maturing of cellar stocks. Raw material requirements for brewing must be determined.

Each packaging facility consists of a number of packaging units. The packaging plan must include the number of shifts to be worked on each unit, which packs should be produced, and on which units this is to be achieved. This plan is developed using the sales forecasts for the various packs and estimated opening stock levels. Other factors that need to be considered are labour requirements and maintenance, as well as major and minor overhauls. Packaging material requirements must also be determined.

The distribution plan should be such that adequate brands and packs are in stock at each depot to prevent any shortages. This is achieved by determining weekly product movements between breweries and depots. Factors that must be considered in the distribution plan are depot capacities, minimum acceptable stock levels, the age of the beer, and fluctuations in weekly movements between the manufacturing warehouses and the depots to ensure stable distribution resource requirements.

Obviously, these plans cannot be developed in isolation, and there should be proper coordination and interaction when these plans are set up. Brand brewing must be sufficient to meet brand/pack packaging, which in turn must be sufficient to meet product movement between breweries and depots. Many production planning problems arose such as insufficient capacity being available for packaging certain packs although more than sufficient cellar stocks of the required brands were available or a specific brand was not available at the brewery where it was needed for packaging. These problems are complicated by the size of the problem. For example, more than 100 000 distinct decisions are required for a planning period of a year. With the manual system this was simplified by aggregating the data. Even so, the process was still too complex for detailed planning. Producing a plan was a laborious task and it took two to three weeks to complete a comprehensive plan. Under such circumstances it was almost impossible to explore and test alternative scenarios, in fact, in most cases only one plan was produced.

4. THE PRODUCTION PLANNING SYSTEM (PPS)

To alleviate the overwhelming task of manually producing a production plan, an interactive, user–friendly decision support system called PPS was developed during 1983. The major components of the system and the sequence in which they are to be used are shown in Figure 1. A short description of the subsystems is given below.

A sales forecast, produced external to PPS and giving expected sales of each product at each depot on a weekly basis for the planning period, serves as an input to the production plan. Although brewing is the first stage in the production process, it is both more logical and easier to meet sales in the planning process via packaging. Therefore, the first step in production planning is to develop a packaging plan based on the sales forecast to ensure sufficient pack stocks for the entire region.

In the packaging subsystem, the packaging planner enters a plan in terms of the number of shifts worked on each of the packaging lines, overtime – if needed – and which packs should be packaged on which lines. Using standard line ratings and operating efficiencies on the packaging lines the pack volumes are computed through simple arithmetic. Week–end closing stocks for the region are also computed and can then be compared with the sales forecast. If necessary, the planner can adjust the plans by, for example, changing the number of shifts or by

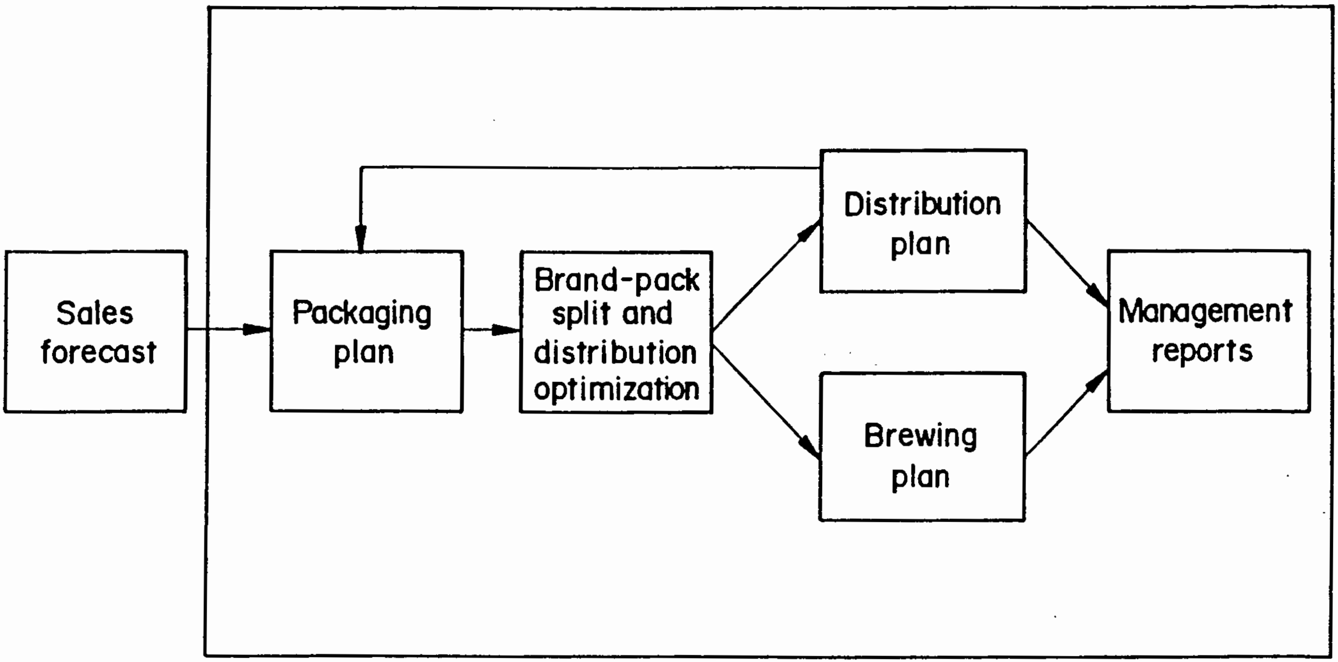

FIG. 1 PRODUCTION PLANNING SYSTEM

using overtime, until there are adequate stock levels. The packaging plan is entered and changed manually while PPS performs the computations and highlights problem areas, out of stock situations, etc. Using these packaging figures, PPS splits them into brand volumes to be packaged in the packs at each brewery. From these figures, packaging raw material requirements can be computed.

The next subsystem of PPS is the one which produces a brand–pack split and a distribution plan. The optimization system uses as input the packaging plan, which is at pack level, and the sales forecast, which is at a brand/pack/week level, to produce a packaging plan at brand/pack/week level and a distribution plan at brand/pack/week level. A full description of the optimization methodology is given in Currin and Ittmann (1985). It suffices to say that the optimization system endeavours to achieve three objectives. Firstly, it ensures that, whenever possible, depot stock levels do not drop below the minimum required levels. Secondly, it attempts to spread excess stocks equitably across all depots proportional to future sales. Thirdly, it minimizes the brewing and distribution costs. Although the system minimizes costs this is not to the detriment of depot stock levels. Customer service is therefore regarded as more important than cost–cutting.

The full optimization problem is a very large transportation–type problem. As PPS is an interactive system, solution time is important. As the problem dealt with here has a special structure, it was possible to decompose it into a number of smaller problems, thereby improving solution times. The optimization model produces a brand/pack packaging plan for each unit at each brewery. A complete distribution plan is provided, giving the weekly brand/pack distribution from the various breweries to the depots.

The brewing subsystem allows planning of brewing to meet brand packaging requirements. This is achieved by specifying the weekly number of brews of a particular brand or the total weekly number of brews of all brands at each brewery. If the total number of brews is specified, PPS will split these figures, based on the packaging requirements for each brand and on the current levels of cellar stocks, into a number for brews of each brand. Alternatively, separate brand brewing figures can be entered into the system.

The interdepot or distribution subsystem is used mainly as a diagnostic tool to identify any problems in the distribution plan. A distribution plan is feasible if the stocks at depots are in excess of a minimum level, called the minimum days of sales and if stocks at "non–depot" breweries, are in excess of the minimum days of production. The stock figures act as a buffer stock against fluctuations in sales and delays in distribution, as well as delays in manufacturing. Problems such as stocks that are below the minimum requirements can be rectified by changing the minimum acceptable days of sales or by increasing packaging on one or more lines.

The management reporting subsystem provides summary reports to top management of the packaging, brewing and distribution plans. These reports provide information on aspects concerning production planning, such as brewery and packaging line utilization, costs of a production plan, etc. This information enables management to have closer control over the production planning process.

5. THE PRESENT PPS

One of the most outstanding requirements of a decision support system is that it should be flexible and adaptable. The system described here operates in a very dynamic environment and is a striking example of flexibility and adaptability. Although the system has been changed and adapted continuously to satisfy new needs and requirements, many features have in fact remained the same. Some of the changes to the original PPS are described very briefly in this section.

The complete production planning system has now been in use since January 1984. It was developed as a medium–term planning system, but very soon became a short–term planning tool. Initially, it was envisaged that the system would be used every quarter to produce updated plans for the rest of the financial and planning year. In practice, the system has been used much more frequently. An operating plan, based on existing profit forecasts, is obtained on a monthly basis. This does not, however, always include the optimization as the latter can be very expensive in terms of computational time. The optimization is run at least quarterly, and from these results an inter–depot plan, which is used for the next three months, is obtained. The packaging subsystem is used on a monthly basis to update operating plans for coming weeks.

PPS has also been used for developing three year plans, and has proved to be a very necessary and helpful tool for longer term planning. This is achieved by running three separate yearly plans, using the closing stocks, etc. of one plan at the end of the year as the opening stocks of the next plan for the next year.

Because the environment in which PPS operates has changed considerably, PPS had to be adapted. A number of extra packaging lines were commissioned while a new brand was introduced. Another three depots were opened in the region, increasing the number of depots to 17. More pack types were also introduced. Although the original design of PPS was such that these extensions to the basic environment could be handled with ease, the size of problem did necessitate extensive alterations to the program and the way in which it operates within the computer. Having been developed using the APL programming language, the entire PPS occupied one work space. With the additions to the basic problem and with the aim of speeding up the efficiency of PPS it now comprises eight work spaces.

Contingency planning has become a reality since the inception of PPS. To develop realistic contingency plans it became necessary to change and adjust the sales forecast. A facility has been added to allow adjustments to be made from within the system, facilitating the generation of contingency plans.

PPS contains a massive amount of detailed information concerning production planning. A number of reports were initially provided, especially for inter–depot planning and for management. This has been extended to provide a comprehensive reporting system on PPS. A specific financial reporting system was added and reports are generated in the form needed by the finance department. These reports are used for stock sheets, costing purposes, etc. The financial costing can be done on a macro level or can be obtained on a decentralized basis. Since the introduction of PPS, the whole region has been divided into a number of districts, and the financial reports can also be provided on a district basis.

There is much input data to PPS, and there often are inconsistencies or infeasibilities in the data. For example, there could be routes between depots and breweries that are "open", which means they can be used, but there are no corresponding costs defined for these routes; there could be no forecast for a particular brand/pack or vice versa; etc. A comprehensive data validation system has been developed to check for this type of data inconsistency. Any problems that are detected are reported by the system. These validation checks were introduced as a cost saving measure, for example, to prevent abortive optimization runs that could be very expensive in terms of computing time.

The original PPS contained only one brewing "recipe" for each brand for a whole year. In practice, however, the recipe may be changed for different seasons and times of the year. A dynamic allocation facility allowing the selection of different recipes for different times of the year has been added to PPS.

6. VALUE AND BENEFIT ANALYSIS

When the proposal was made to develop PPS, no formal evaluation was performed to determine the costs and benefits of the system. Although development costs were minimal, it was impossible to give any indication of running and maintenance costs of the system. A number of advantages envisaged for the system were, however, listed in the proposal document. These included:

(i) quicker production of plans – with an interactive support system production plans would be generated far more quickly than with a manual system, and it would be possible to update plans to reflect changing circumstances more accurately;

(ii) interactive usage – an interactive system encourages the fruitful synthesis of planner and computer. The planners would make those decisions requiring a high level of expertise, while the computer would support them by performing the computations necessary to evaluate the plan accurately and quickly.

(iii) objective measures of performance – because plans would be produced quickly, planners would be able to afford to spend time on looking for better plans. Some of the criteria that could be used in this respect are cost, utilization of facility capacities, labour force utilization, etc.

(iv) reduction of complexity – the problem is extremely complex, and it is difficult to obtain optimal solutions. Previously, planners had to apply heuristic rules to simplify their task – with a computerized system it would be possible to formulate and solve the problem in order to obtain "optimal" solutions.

(v) supporting inexperience planners – with a support system the dependence on experienced planners would be alleviated, and it would be possible for inexperienced planners to perform the planning task. It would be possible for the system to detect shortcomings in a plan and give appropriate warnings.

What has practical use of the system over a period of almost five years shown? A list of benefits and advantages of PPS, mostly qualitative and giving the views of planners and management at different levels, gives an indication of the real value of the system to SAB.

6.1 Quality of Plans Produced

There is no doubt that PPS has improved the quality of production plans, both in terms of the usability and correctness of the plans. It is now possible to generate a number of alternative plans as compared to only one when the manual approach was used. Sensitivity analysis can be performed, and "what if" – type question can be asked and evaluated. Even though it takes the same amount of time to produce a production plan, it is now also possible to compare, evaluate and analyse up to six or seven different planning scenarios and select the "most feasible" plan. Furthermore, it is possible to compare plans in terms of various criteria including total costs.

6.2 Management Involvement in Planning

PPS has involved management much more closely with production planning than was the case previously. It is now possible to present different plans to management and to motivate why a particular plan has been selected. Because it is possible to provide fast feedback, management have started introducing their own philosophies into the planning process and in this way have a direct influence on planning. Any management suggestions can be tried out on PPS, analysed very quickly and appropriate feedback can be given to management.

6.3 New Insights and Learning

Through continued use of PPS the planners have gained much more insight into the planning process. Results obtained from the system are continually questioned, aiding the learning process. The planning process as a whole has become more precise, in turn requiring PPS to become more exact. Another effect is that the business is now operated on a very tight rein, and tactical planning on the short–term as opposed to medium–term planning has become more important.

6.4 Production Costs Awareness

Previously, it was impossible to provide management with detailed costing of production plans. Now detailed reporting on costs is done extensively.

Management at all levels can obtain information on the costs relating to packaging, brewing and distribution and can suggest improvements.

6.5 Ad Hoc and Contingency Planning

During the last four years the South African economy has been plagued by recession–type conditions, which have also affected the beer industry. During this period, labour unrest and strikes have also had a serious affect on production. Therefore, ad hoc and contingency planning has become absolutely essential. PPS has been of great value here since new plans, can be generated quickly taking unforeseen events such as the above into account.

6.6 Complexity Reduction

The scope of the planning problem is very large and complex. This complexity is almost completely shielded from the user of PPS. The system gives the user the opportunity to concentrate on the real task, namely production planning. More in–depth planning is thus possible. Plans can be examined in detail, and compatibility between the brewing, packaging and inter–depot plans is ensured.

6.7 Interactive Use and Flexibility

PPS is a fully interactive system and has proved to be very easy to use. This also applies for inexperienced users and persons unfamiliar with computers. As the system is menu–driven, all possible actions are displayed on the screen, and users should thus have no problems operating the system.

The flexibility of PPS to adapt in a very dynamic environment is another important feature of the system. This has allowed the planning department to accommodate changes, thereby preventing PPS from becoming obsolete.

6.8 General

Other benefits are:

- PPS facilitates improved communication between the planning department and the various breweries.
- The system acts as an important source of know–how. Inexperienced users are supported in tasks with which they are unfamiliar.

- PPS provides an extensive data base of short–term and medium–term information.
- PPS produces a number of exception reports, assisting planners to identify problems, for example, when the right brand is not available at the right brew–house for packaging, or when depots run out of stock. In this way problems that in the past were only detected when they occurred can now be identified during the planning phase and corrective measures can be taken.

7. CONCLUSIONS

In the previous section many benefits of PPS of a descriptive and qualitative nature have been mentioned. The benefits that were envisaged initially, before the system was developed, have been achieved and much more in fact. The widespread, ongoing use and development of the system is an indication of the acceptance and successful implementation of the system. Comments such as "I just can't imagine that we can run our business without PPS" were made during numerous discussions. There is thus no doubt that the system is highly valued within SAB. However, there are still a number of severe limitations. Most important of these is the fact that PPS is a very expensive system in terms of both computer time and use of computer resources, placing a severe constraint on more frequent use of especially the optimization subsystem of PPS. With the current mode of operation the number of optimization runs required has been limited intentionally.

This paper has shown the value of an interactive computer–based support system. As is the case with many similar systems, quantification of the benefits of the system has been very difficult. This does not, however, detract from the fact that PPS is a very useful and valuable system for SAB.

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