COMPUTER AIDED STRATEGIC PLANNING IN CONSTRUCTION FIRMS

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ABSTRACT

Modelling concepts developed to analyse project strategic decisions have been extended and implemented in a computer system leading to a methodology that allows modelling and evaluation of strategic planning decisions in construction firms. The system uses concepts of cross-impact analysis and probabilistic inference as the core of the analysis procedure. A simple questioning process is used to guide the discussion and elicit information in an ordered manner. The result is a powerful but easy to use computer modelling system where managers, or other potential users, are not exposed to the complexities of the mathematical model.

A computer system implemented in a Windows 95 platform provides a graphical interface to help the users in building a conceptual model for the decision problem, the firm and its environment. The model is a simplified structure of the variables and interactions that influence the decisions, including internal variables as well as external variables which represent the external environment of the firm. The system provides powerful analysis capabilities, such as: sensitivity analysis, to identify the most important variables in the decision problem; prediction of selected outcomes for a given strategy, scenario analysis, to test strategies under different environmental conditions; risk analysis, to identify the risk involved in different alternatives; comparative analysis of the effects of alternative firm strategies on individual or combined performance measures; explanatory capabilities through the model causal structure; etc.

Keywords: Strategic planning, strategic decisions, strategic management, and construction firms.

1. INTRODUCTION

The dynamic nature of today's construction industry compels owners and contractors to pursue strategies that improve performance. The ongoing changes and fierce competition of the construction sector exacerbate the ability to predict implications of strategic decisions on company performance. However, decisions are usually made using limited analysis and based on intuition, or evaluated using conventional approaches, which ignore risks and uncertainties. The first author, working with a Construction Industry Institute's task force, developed a methodology originally intended to predict the effect of project options such as construction incentives, project organisation and team building on project performance (Alarcón & Ashley 1992, 1996). This methodology applies concepts of cross-impact analysis and probabilistic inference to capture the uncertainties and interactions among project

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variables allowing the explicit incorporation of these elements in the decision analysis process. This methodology has been further developed and applied to other decision problems in the last five years (O'Ryan et al 1997), (Akel et al 1996), (Venegas & Alarcón 1997).

This paper describes the application of this modelling methodology to the evaluation of strategic planning decisions in a construction firm using GPM 2.0 (General Performance Model), a computer implementation of the modelling concepts, developed by the second author, which include a highly interactive interface to support the modelling process. So far, this methodology has been applied in four construction firms with very good results; several other cases are currently under study.

The system has been implemented in a PC microcomputer platform for Windows 95 & Windows NT, using the development environment Visual of Microsoft, programming language C ++. The hardware required to operate the software is PENTIUM or better machines with at least 16 MB RAM and a minimum of 30 MB of hard disk space available.

2. MODELING PROCESS

Building a Conceptual Model of the Firm and External Environment

The computer system has a graphical interface designed to help the users in building a conceptual model, which represents the variables, and interactions that influence the strategies under analysis. As an example, Figure 1 shows the conceptual model developed to analyse strategic decisions for PRECON Inc., a construction company.

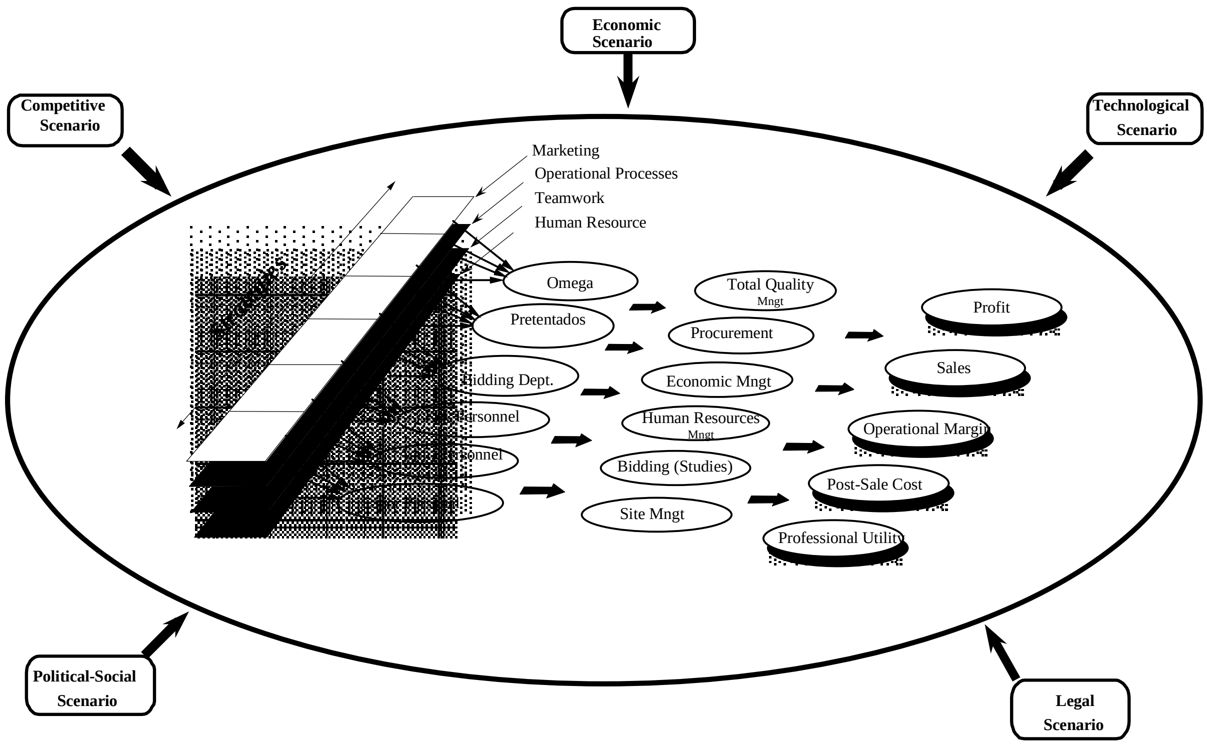

Figure 1. Conceptual Model for Company Performance

The model was built by the company managers to analyse the impact of prospective strategies on the company strategic objectives. It has six levels (from left to right): external agents, strategies, internal agents, process, outcomes and combined performance. Starting with the left-hand side of the model, each layer represents alternatives for each strategy, for instance, several alternatives for a marketing strategy or a human resource strategy. There are many alternatives and combinations of alternatives for each strategy. A specific marketing plan can be combined with a specific human resource program and choices among the other option areas to form a combined strategy.

Figure 2 shows the model-input screen with GPM release 2.0. Following the strategies or decision options there is a set of variables that is directly affected by them; these variables are called internal agents. Each alternative strategy is assessed as to its probable impact on internal agent. The internal agents, in turn, propagate these effects through interactions among themselves and with processes. The model is defined as a set of variables whose effects propagate from left to right, where each variable is modelled internally as a set of five mutually exclusive and collectively exhaustive events. The events represent the existing range of performance for each variable.

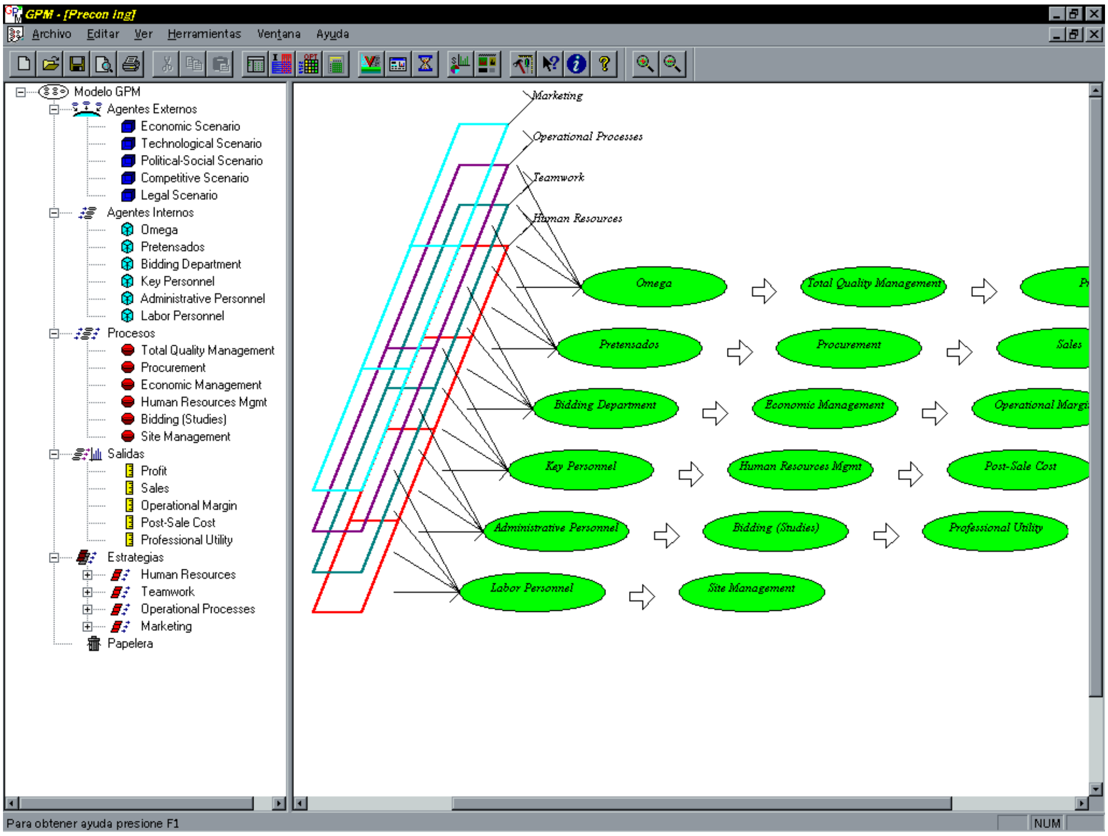

Figure 2. Model Input Screen

Assessment of Strategies' Effects

A strategy represents the decisions under evaluation in the model. The effect of the strategies on internals agents of the model must be specified for different alternatives. For instance, in the example shown in Figure 1 an alternative can be characterised by the presence or absence of certain strategy characteristic. The user must specify the main characteristics that will define the strategy and the system automatically generates all the possible alternatives. Figure 3 shows the alternatives generated by the system to represent different first order strategies; a similar table can be created for each one of the specific strategies when their characteristics have been specified.

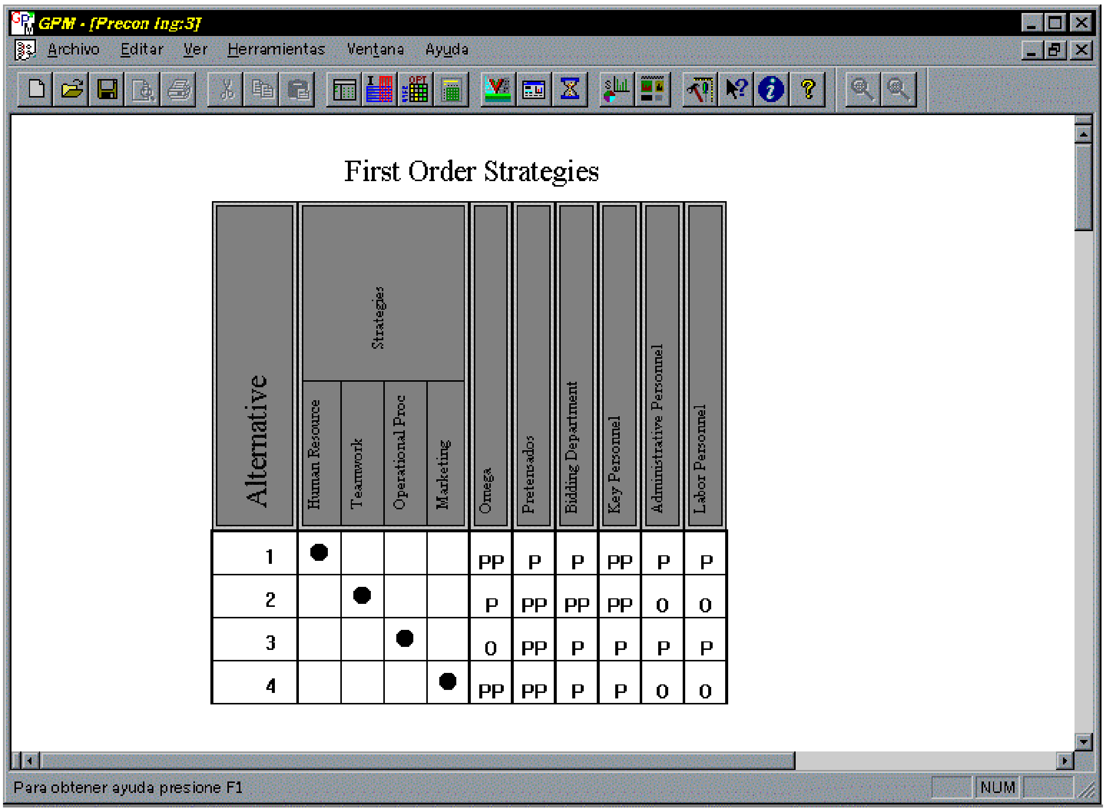

Figure 3. Impact of Alternative Organisations on Internal Agent

The effects of each alternative on the model internal agents can be assessed using a conventional scale defined by the user, as shown in Figure 4. The scale considers potential for both positive and negative impacts using five symbols to cover the range of possible outcomes. Each scale symbol is associated with a probabilistic definition. For instance, a high positive impact (PP) on a driver can be defined as one in the upper 20 % of the impact scale. Similarly, a high negative impact can be defined as one in the lower 20 % of the impact scale and the rest of the symbols can be associated to values in between the extremes. A PP (high positive impact) assessment in Figure 3 means that the selected type of strategy will improve the ability to realise the internal agents potential beyond a level with only 20 % probability of being exceeded.

State	Definition
NN	High negative impact
N	Medium negative impact
O	No significant impact
P	Medium Positive impact
PP	High positive impact

Figure 4. Impact Scale

Each impact must be assessed individually for each internal agent, without taking into account interactions with other internal agents. These types of assessments can be independently collected from specialists for each option such as marketing plans, human resources or teamwork.

Cross-Impact Information

The mathematical model uses concepts of Cross-Impact Analysis (Honton et al, 1985) and Probabilistic Inference. Cross-Impact Analysis (CIA) is a technique specifically designed to study how the interactions of events, present in a mathematical model, affect the probabilities of those events. It is used to analyze the numerous chains of impact that can occur, to determine the overall effect of these chains on the probability that each event will occur. The Cross-Impact concepts have been adapted and extended (Alarcón & Ashley 1998). Among the extensions, a method to combine probabilistic evidence is applied in this system to perform probabilistic inference.

Once the model variables have been identified and input into the computer system, influences and interactions among variables are collected and stored in matrix format. Figure 5 shows a representation scheme developed automatically by the computer system to collect information in the form of a simplified cross-impact matrix. The assessments can be obtained from experts or members of the management team, depending on the type of knowledge required. The users must answer the following question: "If changes were to occur in the column states, how would this affect row states? ". The respondent must indicate the strength and direction of the "*impact*", according to the scale shown in the upper left corner of Figure 5 that is represented by key word or colours in the screen to facilitate review of the assessment process and to obtain a general view of the impact structure of the model.

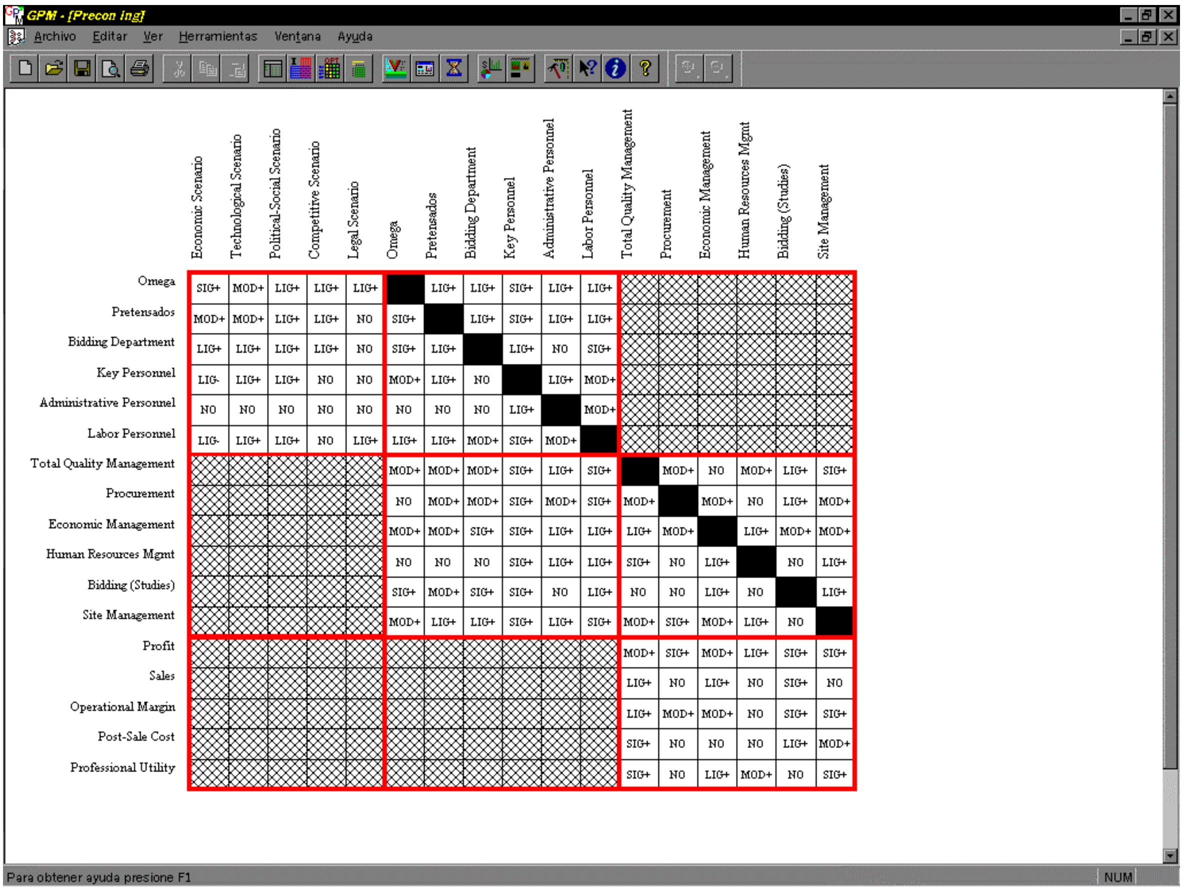

Figure 5. Simplified Cross-Impact Matrix

The questioning process is repeated for all the pairs of variables in the model until the full "occurrence" matrix has been completed. Different parts of the matrix can be filled by different experts or members of the team depending on their experience and knowledge, in this way the matrix becomes a tool for integrating knowledge from different sources. The simplified questioning process described above is used to collect the basic information for the CIA used in the mathematical model. Details on the procedure can be found in (Alarcón & Ashley, 1998).

Outcome Measures for Strategic Objectives

In the next step of the modelling process, users must define the outcome measures they want to use to evaluate their decisions. Six outcome measures were used in the example shown in Figure 1. The system requires a clear definition for each outcome in order to facilitate understanding of all the participants in the modelling process. Figure 6 shows the input screen for performance measures, using Sales for 1998 as an example.

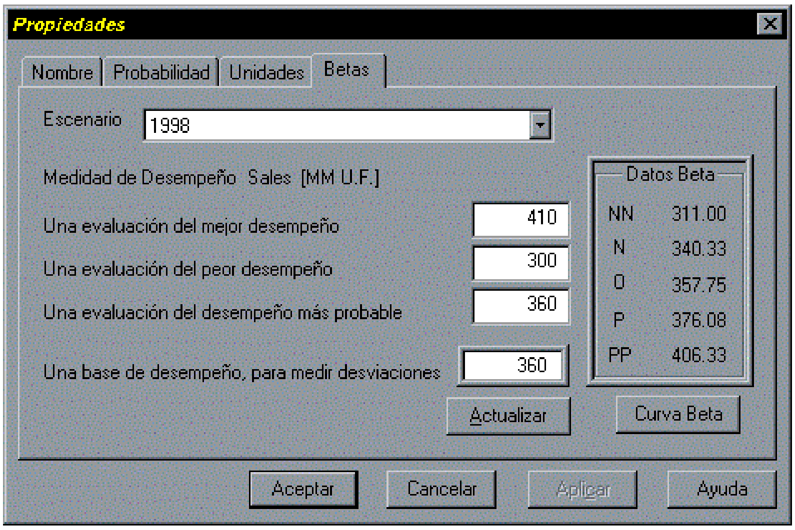

Figure 6. Input Screen for Outcome Measures

Once the outcome measures are defined, the users must provide assessments about the variability of the outcome measures using an approach similar to that used in PERT. A pessimistic, optimistic and most likely value for the performance outcome must be assessed. These assessments are used to approximate a probability distribution to represent the variability of the outcomes in the mathematical model calculations.

3. ANALYSIS CAPABILITIES

Sensitivity Analysis

Figure 7 shows the ability of the system to provide sensitivity analysis of the different outcome measures to each of the model drivers. The horizontal axis represents the conventional performance scale for the drivers where NN represents the worst performance and PP represents the best performance. Figure 7 is a summary result of the sensitivity analysis; the pie charts show the relative impact of all the Internals Agents on each performance outcomes. For instance, for Sales the Internal Agent with the highest impact is “Key Personnel” and “Administrative Personnel” is the one with the lowest relative impact. Similar analyses can be made for each variable in the model, helping the decision-maker to identify the most relevant variables present in a decision.

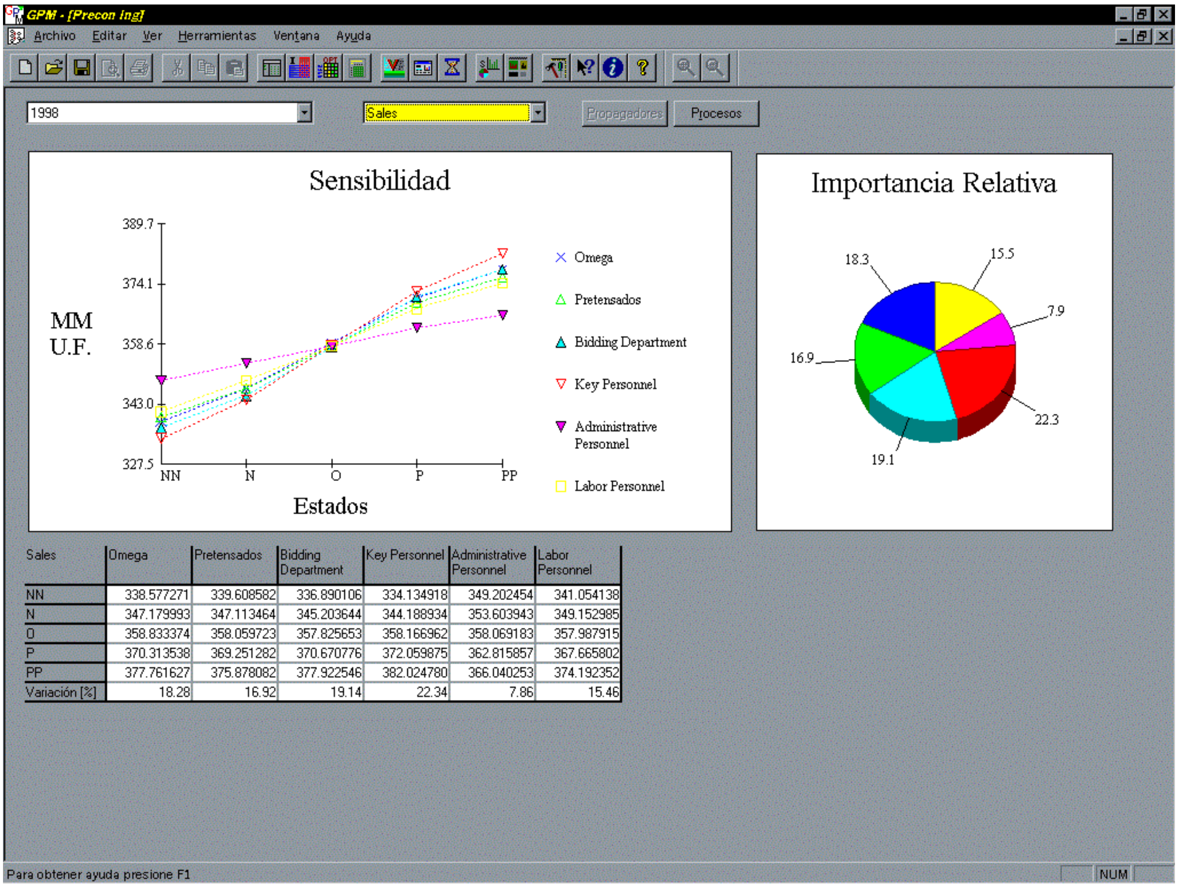

Figure 7. Outcome Measures' Sensitivity to Internal Agents

Selection of Strategies

Figure 8 shows the effects of first order strategies on Sales. This analysis can be used to compare alternative strategies. The same analysis can be carried out to compare different alternatives for a given strategy, for instance, users can visualise the impact which selecting alternative marketing strategies may have on Sales or other performance measures and select the best feasible alternative for the particular strategy. A careful review of the results can help the user gain a better understanding of the implications of strategy characteristics and the gains or losses that may result from making changes in their design. At the same time, this information can help to design more efficient monitoring and control procedures within the company.

The system can perform this analysis under different external conditions; represented by the external agents; in this way the system can help the user to analyse the stability of selected strategies to changes in the external conditions. The system can perform many other different analysis, such as: prediction of selected performance outcomes in different timeframes; risk analysis; comparative analysis of the effects of alternative management actions on individual or combined outcome measures; explanatory capabilities through the model causal structure; etc.

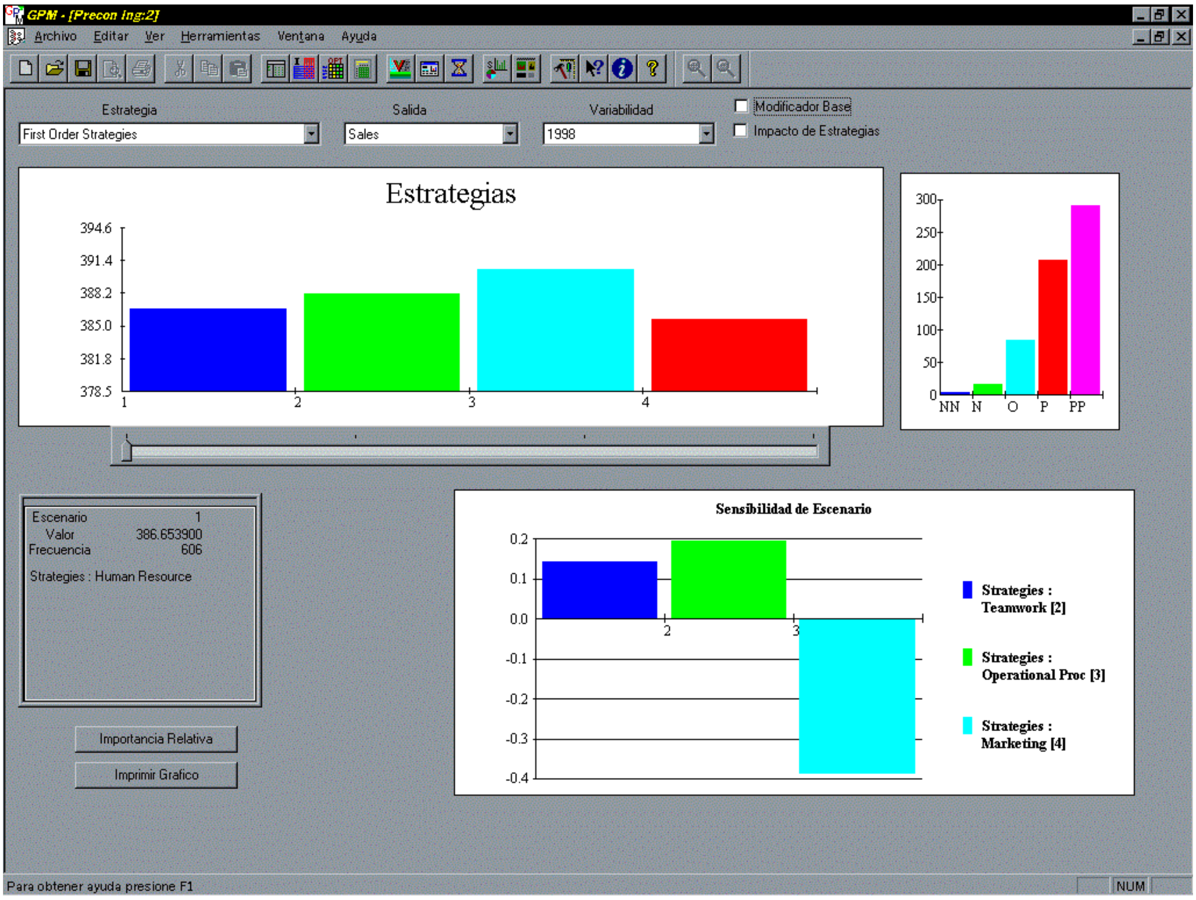

Figure 8. Benefits of First Order Strategies

4. SUMMARY AND CONCLUSIONS

The computer implementation of this modelling approach allows the development of a sophisticated model presented in a simple form for the decision-makers. The model can be built in a short period of time, with a reduced amount of effort and preliminary analyses, performed earlier in the modelling effort, can help to refine and perfect the model. The computer model used as an example was developed in a single three hours modelling session. Previous modelling efforts, with a limited computer implementation, took three to four times longer, in a period of several weeks, to produce similar results.

Acknowledgements

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