A SIMULATION OF A BUSINESS FIRM

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Summary

This paper describes a simulation model of a hypothetical business firm. The model was constructed to include not only the accounting and economic factors of costs, profits, sales, units produced, etc., but also psychological and behavioral concepts. Individuals in the firm have aspiration levels, feel pressure, and react in accordance with behavioral theory.

The purpose of the model is to study the effects of informational and organizational factors upon the decisions of a business firm. We have had limited knowledge of such variables as: the effects of tardy information, the effects of different distributions of information within the firm, the effects of differing degrees of centralization or decentralization, etc. A comprehensive model, such as the one proposed, is necessary to answer such questions.

Eight specific hypotheses involving changes in the organization and information system of the firm were formulated and tested using a factorial experimental design. The results of this experiment demonstrate the usefulness of this model as a research tool.

Introduction

In studying information systems in business firms, management accountants and data processing students have been rightly concerned about the effects of informational variables upon decision-making. It is generally agreed that factors such as: kinds of information received; amounts of information received; distribution of information; and the timing of said information are important in designing a data system which will enable management to make good or "best" decisions. But little evidence, either theoretical or empirical, has been advanced about these factors.

On the one hand, the theoretical models that have been constructed (such as the Marschak-Radner Theory of Teams) have been too simple to be of use in studying information flows in the large complex business concerns of today. The experimental work, too, has been largely limited in scope, dealing with simple information in simple network structures.

On the other hand, much progress has been made in recent years in the data useful for what might be called micro decision-making. That is, decision-making at the individual level. Part of this progress has been the result of the development of Management Accounting, especially budgeting and cost accounting. Another part has gone hand in hand with the rise of Management Science and the development of mathematical and statistical models for decision-making. But the area which could be called macro decision-making has been largely ignored. Here we are concerned not only with information's effects upon a particular decision-maker, but also its effects upon the business organisation as a whole.

The need, then, is for a model or framework that the theorist can use to study the effects of information and related organizational factors upon decision-making in the whole firm. Such a model must be:

1. A complete systems model, so that effects can be traced throughout the firm

2. A model embodying psychological and behavioral principles--since the manner in which information is transformed into action should be included

3. A model complex enough to fairly represent the real world.

The model described in this paper is an attempt to meet these criteria.

Note that the information theorist is not the only one to benefit from such a model. Organisation theory, also, needs a formal model within which to study the effects of changes such as: changed emphasis of authority, or the question of centralization versus decentralisation. Also, in economics, we see numerous areas where a complex model of the firm could be of much use. The economic theories concerning behavior of business firms in oligopoly market situations has been seriously handicapped because they lack the inclusion of factors internal to the firm. (In oligopoly markets, the firms have some influence over the market. This influence is often an offshoot of the organizational structure of the firms, the information systems of the firms, etc.) However, economists are beginning to realize the need for more complex models.2 The sub-discipline of the Behavioral Theory of the Firm is becoming an accepted part of economics.3 It is within this framework that the present model is to be viewed.

The Model

We have described, in part, the functions that an adequate model of the firm can fill. In this section, we shall discuss the particular
model that we have constructed. The method of experimentation with the model is to change its components. For example, we could change the formal organization or a particular link in the information system. Thus, for our study, it is not the specific parts of this particular model that are important, but the general form by which the model is constructed.

Ideally, the model of the firm is an attempt to build a formal structure, using as much of the inherited bodies of theories from Economics, the Behavioral Sciences, Organization Theory, and Management Accounting as are relevant. Such a model is so complicated that we could not manipulate it analytically. Thus, we must be content with a simulation study, intended to represent the behavior of the firm over a simulated period of time.

The formal organizational structure of our model is shown in the chart. Essentially, the company contains (a) an executive committee that does the planning, the co-ordinating, and acts as the "top" controlling function of the firm. The (b) sales branch contains a general sales manager, seven sales districts (each headed by a local manager), and some forty salesmen. The (c) production division contains a vice-president for production, a plant manager, five foremen, and an industrial engineering department. The decisions made by each are described in general terms in the chart.

Each "decision-maker" (person or group) in the organization behaves according to a specific predetermined procedure, which we shall call a decision rule. Information, gleaned from the information system of the firm, is fed to the decision-maker and enables him to use the decision rule. (For example, a vice-president may abide by the decision-rule: "Set price 10% above cost." To utilize the rule, he must know what figure represents cost.)

How are behavioral concepts built into the model? As an example, the executive committee has a set of decision rules by which it controls the firm. The decision rules blend psychological theories on aspiration level and observable business practice. The specific profit goal of the firm is a function of past profits. Now, if estimates from various departments, the projected profit does not measure up to the executive committee's goal, modifications in their plans are tried. (I.e., if a gap between aspiration level and reality exists, search is initiated.) They may: (a) cut costs, (b) try to increase sales, (c) change price, or (d) if all else fails--lower the profit goal. This process continues until a satisfactory projected profit is reached.

Another behavioral concept built into the model is pressure. Each individual has an "index of felt pressure." This index is intended to represent the sum total of all the various pressures exerted upon the decision maker. As a specific example, the factors making up the index for a salesman are listed below, together with the weights attached to each factor.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Index of pressure of his superior (the district sales manager)</td>
<td>25</td>
</tr>
<tr>
<td>2. His quota relative to his sales in the past month</td>
<td>40</td>
</tr>
<tr>
<td>3. Sales of the average salesman in his district relative to his sales</td>
<td>10</td>
</tr>
<tr>
<td>4. .75 + (percentage of his products less than 75% of quota)</td>
<td>10</td>
</tr>
<tr>
<td>5. His total quota for the past quarter relative to his total sales for the last quarter</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

These represent, more or less, the formal factors affecting the salesman. Of course, a large number of informal factors could theoretically be added, such as personality conflicts with his superior, etc. Note how the index provides a connection between information flows in the firm and a behavioral variable, namely pressure. As pressure mounts, individuals react (although not to the same degree or in the same way). As pressure diminishes, a phenomenon called "organizational slack" gradually develops and results in inefficiency within the firm. An example of organizational slack would be a tendency toward "empire building": (i.e. when business is profitable, the occurrence of excessive advertising, over-staffing, etc.) Also, information is transformed into action via pressure. Thus, a salesman feels pressure depending upon reported sales, costs, and profits (information); the salesman may then expend more sales effort (action to conform with what is expected from him).

In addition to psychological concepts, a variety of business rules are inculcated into the model. Thus, the decision rules by which budgets are set, production scheduled, and standards determined are inherited from business practice. Market behavior is represented in accordance with standard economic demand theory.

Computation and Experimental Design

Our model was programmed in FORTRAN to run on the IBM 7090. (Each run of 108 periods took about 2/3 minute.)

Eight hypotheses (representing changes in the organization or information system of the firm) were selected for study. Space limitations...
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prohibit our explaining the eight major hypotheses of the model in detail. We shall enumerate them, however:

Changes in the External Environment of the Firm:

1. External World Variability. (Stable costs and sales versus fluctuating costs and sales.)

2. Market Growth Trend. (Slow cyclical pattern of market growth versus fast irregular growth.)

Changes in the Decision System:

3. Loose vs. Tight Industrial Engineering Department. (Loose or tight standard costs.)

4. Amount of Contagion of Pressure in the Firm. (Degree to which an individual transmits his "felt pressure" to his subordinate.)

5. Sensitivity of Individuals to Pressure.

Changes in the Information System:

6. LIFO vs. Average Cost Method of Inventory Valuation.


A 2^8 factorial experimental design was utilized to evaluate the results.

When testing the outcome of a change in our model, the question arises, "Is this result applicable to only this specific type of firm?" By use of the factorial design we have built in eight hypothetical firm "differences" the combinations of which can give us a large number of firms. Now we can test our result against a "many-faceted" background of firms to see if the result is consistent.

In essence, then, our model is similar to a laboratory experiment. We can control all the factors of a "real-life" business firm, make changes, and record the effects of these changes. Again, while our model is still a simplification of reality, it is more complex and can answer a broader range of questions than before.

Some Significant Results

The effects of the experiment as they relate to information theory are:

Effect of LIFO

The major effect of the use of LIFO versus the average cost method of inventory valuation was a significant increase in sales, pressure, and profits within the firm. And since the model did not include taxes, this increase in profits was not attributable to tax benefits.

How was this result achieved? LIFO, when used for internal reporting purposes, increased the variability of profits from period to period. The average cost method, on the other hand, tended to smooth out costs (by averaging) and hence produced more stable profits from period to period. The fluctuating profits under LIFO tended to keep the firm "on its toes" and quick to take advantage of cost saving and profit making opportunities. The firm with the more constant profit picture was more sluggish.

The importance of this result is not that it proves LIFO as the best policy, but that some surprising unintended results came from what appeared to be a simple accounting procedure. The result was achieved because the information affected others in the firm than those intended—those external to the firm. Tax savings and external reporting should not be the only considerations in deciding a policy of inventory valuation.

Knowledge by the General Sales Manager of the Company Inventory Position

There was no significant difference in the sales or profits of the firm depending on whether or not the general sales manager knew of the inventory position of the company. The conclusion is that this information (about inventory) was not useful to sales in this case and may not be useful in others. Future research can specify when such information is useful and when it is not.

Loose vs. Tight Production Standards

We had the Industrial Engineering Department tighten up its standards with a resultant cost cut. However, profits did not rise. Why? By producing cheaper, one need sell less to make the same profit. And the sales force felt the ease in pressure and equaled out the cost cut by lower sales. The implication for organizational theory? Perhaps a "cost-cut type" campaign is not effective when viewing the firm as a whole. As then, alternatively, pressure on the sales force may cause a simultaneous "ease-up" for the production people.

*LIFO is often used for external reporting only, whereas we used it for internal reports also. In addition, it is possible that the same result achieved by LIFO, could be obtained by FIFO or by a standard cost system. Future research will investigate these possibilities.
This result poses an interesting question for information theorists. On the surface it would seem desirable to give individuals information about the progress of the whole organization. They could thus see their contribution to the over-all effort and be motivated to perform better.

But the result here is exactly the opposite. The effect of a cost reduction is balanced by an "ease-up" in the sales department. Knowledge of the over-all profit level caused poorer performance, rather than the reverse.

Conclusion

On a small scale we have set up a reasonable facsimile of how individuals behave within a firm. We have used this model to study changes in the information and decision system of the firm, with some surprising results. These results are at least suggestive of phenomenon that can happen. They do open up new fields of inquiry. And they show that this type of model is quite valuable as a research tool.

Acknowledgements

This research has been sponsored in part by the Office of Naval Research and in part by the Western Management Science Institute. The computation was performed at the Western Data Processing Center, University of California at Los Angeles.

The author is deeply indebted to R. M. Cyert and W. W. Cooper for guidance and innumerable suggestions during the course of the research. In addition, Fred M. Tonge and Daniel Teichroew offered helpful comments on this paper.

References


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ORGANIZATION OF THE SIMULATED FIRM
(including types of decisions at each level)

EXECUTIVE COMMITTEE
1. Determines final sales, cost & profit expectations
2. Sets budgets
3. Exercises control over vice-presidents

VICE-PRESIDENT FOR PRODUCTION
1. Makes preliminary cost & budget estimates
2. Sets the target volume of operations
3. Exercises control over production supervisor and industrial engineering department
4. Influences administrative expense

GENERAL SALES MANAGER
1. Makes preliminary sales estimates
2. Sets quotas and budgets for sales districts
3. Exercises control over district sales managers
4. Influences administrative expense

INDUSTRIAL ENGINEERING DEPARTMENT
1. Revise production standards
2. Influence administrative expense

PRODUCTION SUPERVISOR
1. Set actual volume of operations
2. Request revisions in production standards
3. Exercise control over foremen
4. Influence administrative expense

DISTRICT SALES MANAGERS
1. Make preliminary sales estimates
2. Bargain with salesmen about quotas
3. Exercise control over salesmen
4. Influence administrative expense

SALESMEN
1. Make preliminary sales estimates
2. Bargain with district about quota
3. Expend sales effort

FORMEN
1. Initiate requests for revisions in standards
2. Influence variable manufacturing costs

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