Business Games – Algorithms for Market Data Generation

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Abstract: This paper implements an algorithm for calculating the market share for some firms that act within a business game. The first part of the paper makes a short introduction to business games. The second part of the paper describes the strategy needed for developing a business game, whereas the third part describes some of the models implemented in a business game with emphasis on the algorithm used for calculating the market share for the firms competing on the same market.

Key-Words: - business games, market, data generation, demand satisfaction

1. Introduction in business games

For practicing a successful management and ensuring an efficient use of resources within an organization, the managers need to have a series of specific qualities and abilities that could be acquired and improved by learning. The learning process is usually based on experience and one of the most effective means of learning through experience is using business games, both in the initial training of economist in universities and business schools, and in the continuous learning for specialists and managers in organizations.

Business games, also known as economic simulation games or business simulation games[12], represent “simulation models encompassing many participants engaged in the information and decision making processes that simulate a real competition”[10] or, in other words, a dynamic simulation exercise of sequential decisions, which is structured around a business where the participants assume the management risk.

Generally, games are meant for simulating the future of an organization and of the context in which the organization develops. The decisional managerial simulation consists in creating a managerial model based on identifying and establishing some logical relations between variables that define a typical managerial decision and have a certain periodicity. Based on this, several decisional alternatives are projected for determining the effects. The model underlying business games consists of [1]:

- the simulated organization, including its components and specific interconnections;
- the economic context, represented by the elements of the environment the organization interacts with: the market, the clients, the competition etc.;
- the decisions of the gamers as regards the main activities of the organization;
- the intermediary or final results based on decisions and the economic context.

Simulating economic processes via games aims at increasing the skills and abilities in management, based on the idea that the ability could be acquired by practice and not by learning theories.

2. Developing game models

The game operation is based on the development model of the simulated system that is established according to the general scope and particular objectives. At this point, the connection between the economic reality and the aspects/elements chosen for being simulated is accomplished. This stage also establishes the game development rules, the information flow, the forms used in the game, the procedures to be automated and quantitative models required by these procedures.

After studying and analyzing the real system, the next stage in building the game consists in reducing the dimension of the process, in abstracting the model. The game is built around a core that consists of a quantitative model obtained by rationalizing the qualitative one by quantifying the relations between variables and parameters by means of data. Generally speaking, the game model consists of rules and procedures in compliance with which the
games progresses, representing an approximation of the real processes.

The specific rules for this game endorse the main elements that influence its course. They are presented in what follows, so that the game mechanism could be better understood:

The market is considered an economic mechanism where the demand meets the supply. In the proposed game, the environment where the organizations do their business is represented by the total market, but we could also consider the market for each product. The size of the demand in our model is a random one.

The maximum potential demand represents the total demand of goods on the market at time $t$. It will be generated by the game and it will only be referred to by the organization at the beginning of each month for planning its production. It can be calculated only on demand, against a fee, and it consists of:

- the sales history for the current year combined with the sales at the moment $t-1$;
- the conjectural index.

The real demand represents the total demand of goods on the market at the end of the period $t$ and it suggests the quantity that the consumers could buy for a certain product, in a certain period. It will be generated according to the decisions taken by the players and it is the base for calculating the volume of sales for each month. It is calculated taking into account:

- the history of sales for the current year combined with the sales to the moment $t-1$;
- the conjectural index;
- the global impact index of the marketing activity for the period.

The conjectural index is a random factor that reflects the consequences of the economic and social evolution over the demand, over the economy in general. This creates the random behaviour of the economic activity.

The global impact index of the marketing activity can be determined according to the total amount invested in marketing by all the players. The activities of each organization, mainly aiming at getting the best possible market share, do not only influence one’s own organization, but it can lead to a growth or decrease of the total demand on the market by applying a global pressure on prospective buyers.

The market shares encompass all the consequences triggered by the decisions taken by the players in a certain period and represent a barometer for each organization’s activity. The market share is calculated in percentages as part of the market dominated by the organization against the competition. It consists of several quantitative indicators:

- Production - the volume of supply for each organization;
- Sales price – all the prices for all the products in sales for a month are analyzed;
- The quality of the products – the product quality level increases or decreases the place of an organization on the market;
- The marketing budget assigned by a firm for promoting its products is composed of the volume of promotional expenses for period $t$;
- Consumer sympathy – brand attraction, organization image, its reputation.

The final performance index for each firm is the indicator for calculating the final classification and the winner of the game. It is calculated by analyzing the total activity for a player and its qualities, taking into account the intermediary results of each month but also the performance level in the last month. The arbitrage method is a rigid and objective one and is calculated taking into account:

- the firm’s assets at the end of the simulation – the turnover, the profit, the value of stocks and debt rate;
- demand satisfaction degree;
- level of forecast objectives;
- average market share for the entire game.

Solving the model falls back on different algorithms and equations. The processes that take place on the market are simulated by means of economic and mathematic models that take into consideration many variables.

Demand generation algorithm

For obtaining the volume of demand, we decided to apply the statistical method of forecasting with mean deviation. The chronological series used equals the sales over the last twelve months. The steps for generating the demand are as follows:

$S_1$: The mobile deviation is calculated for each period $\Delta_{t/t-1} = y_t - y_{t-1}$

$S_2$: Mean deviation is calculated

$$\bar{\Delta} = \frac{\sum_{i=1}^{n} \Delta_{t/t-1}}{n}$$

$S_3$: Demand for current month is calculated

$$y_n = y_0 + t_1 \cdot \bar{\Delta}$$

where $t_1$ - time variable regarding the base (the position of that term against the term chosen as a base)

$S_4$: for creating a random value, the value from $S3$ is adjusted with a random variable; also for taking into
account the global marketing actions, we adjust the index of the marketing budget, each having a certain weight.

\[ I_{BMK} = \sum_{j=1}^{n} BMK_j \] ; \[ CT_n = \frac{70}{100} \cdot y_n + \frac{15}{100} \cdot y_n \cdot r\(\text{and}\() + \frac{15}{100} \cdot I_{BMK} \cdot y_n; \]

And its implementation for a certain product:

```java
public void demand_generation(int productID)
{
    SalesController vc = new SalesController();
    List<SalesInfo> Sales = vc.History_Sales_list(productID);
    double s = 0;
    for (int i = 1; i < Sales.Count(); i++)
    {
        int growth=Sales.ElementAt(i).quantity-Sales.ElementAt(i-1).quantity;
        s += growth;
    }
    s = Convert.ToDouble(s) / 12;
    double theoretic_demand = (double)(Sales.ElementAt(0).quantity + s * (12 + luna_currenta()));
    decimal bmkt=Decisions_products.Total_MarketingBudget(product, current_month);
    double real_demand = 70.00 / 100 * theoretic_demand + 15.00 / 100 * Random.NextDouble() * theoretic_demand + 15.00/100*(bmkt/5000) * theoretic_demand;
    DemandInfo demand = new DemandInfo ({demand.cod_cerere =3, productID = productID, month = current_month(), valoare = Math.Round(real_demand)});
    Demand.Add(demand);
}
```

**Market share algorithm**

The competition processes on the market economy are very complex and difficult to be calculated. In order to simulate various competition situations, there are several models that are able to detect certain characteristics of the economic processes, given the existence of several competing organizations.

The model chosen in the game is based on an algorithm for establishing the market share that is based on abstracting the processes and interpreting the influence factors in several ways mathematically and economically. Also, this algorithm is based on the algorithm presented in [7].

**Input data**

For calculating the market share we consider the data from the initial period, before the beginning of the game:
- Table of sales distribution at the moment \( t_0 \)
- Influence indexes, consumer attraction at the moment \( t \)
- Forecast of the real demand at the moment \( t \)

![Table 1. The model of sales distribution on the market.](chart.png)
where: \( i = 1, m \) – no of products; \( j = 1, n \) – no of firms competing on the market;

And: \( N_{ij} \) – sales of product \( i \) by firm \( j \); \( CT_i \) – total real demand for product \( i \); \( V_j \) – total sales of firm \( j \); \( CP_j \) – market share of \( j \);

**Data processing**

For correctly emphasizing the decision of each player over the market, it is necessary to study the influence of the main factors:

- **Product quality**

Considering the main quality components, a score is established for the products produced by each firm, which may range between \([0..100]\), according to the quality level selected by the player.

\[
CAL_j = \sum_{t=1}^{m} \text{CAL}_t^j+ \sum_{t=1}^{n} \text{CAL}_{tj} + \ldots + \text{CAL}_{mj}
\]

The players may set a quality level for their products during the game: low, medium, high.

<table>
<thead>
<tr>
<th>Quality level</th>
<th>Score</th>
<th>Cost</th>
<th>Interval</th>
<th>Research level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>10</td>
<td>3€</td>
<td>0–30</td>
<td>Type 1 research</td>
</tr>
<tr>
<td>Medium</td>
<td>10</td>
<td>4€</td>
<td>40–60</td>
<td>Type 2 research</td>
</tr>
<tr>
<td>High</td>
<td>10</td>
<td>6€</td>
<td>70–100</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Quality levels.

Advancing to the next quality level is possible through investments in research.

- **Sales price**

Consumer attraction for a certain product is inversely proportional with its price level and it is represented by the price attraction index \( I_{\text{PRET}} \).

- **Marketing budget (Bmk)**

This attraction factor depends on the funds assigned for marketing and publicity. The players may set an amount of money in several ways, applying promotional strategies by means of Publicity, Promotions and Ads.

Each marketing strategy has a certain weight in influencing the results on the market. Consequently, the investment in publicity weights 20%, the budget for ads 50% and the promotion of products 30%. If the player spends too much money in marketing, the influence would not be so high.

\[
Bmk = \frac{20}{100} Bmk_{\text{publicity}} + \frac{50}{100} Bmk_{\text{ads}} + \frac{30}{100} Bmk_{\text{promotions}}
\]

- **Consumer sympathy** (brand attraction, firm’s image, reputation)

It is influenced by: the budget allotted to sustainability, implication in the social life, education, humanitarian campaigns, demand satisfaction degree, creating new products, product support. We represented the sympathy on a scale from 0 to 10:

\[
P_{\text{sustainability}} = 3 \cdot \frac{\text{Allotted Budget}}{5000}
\]

\[
P_{\text{social activity}} = 3 \cdot \frac{\text{Allotted Budget}}{20000}
\]

\[
o 2 \text{ points} – \text{demand satisfaction degree};
\]

\[
P_{g \text{ demand satisfaction}} = 2 \cdot \frac{G \text{ Demand satisfaction}(%)}{100}
\]

\[
o 2 \text{ points} – \text{product support (cost: 2€ / product)}
\]

\[
P_{g\text{garantea}} = 2 \cdot \text{Decision}(0/1)
\]

The formula for calculating the grade for consumer sympathy for each firm is the following:

\[
SIM = P_{\text{sustainability}} + P_{\text{social activity}} + P_{g \text{ demand satisfaction}} + P_{g\text{product support}}
\]

The calculation of the market share is performed in several steps:

\( S_1 \): Calculation at the moment 0 of the matrix \( A (a_{ij}) \)

\[
i = 1, m , j = 1, n , \text{using the following formula:}
\]

\[
a_{ij} = \frac{N_{ij}}{CT_i}
\]

\( S_2 \): Consumer Sympathy for product \( i \) of firm \( j \)

- the calculation of this coefficient takes into consideration the influence of several factors that are evaluated quantitatively by determining several influence indexes:

\[
I_{\text{CAL}} = \frac{\text{CAL}_i^j}{\text{CAL}_i^{j-1}} , I_{\text{BMK}} = \frac{\text{BMK}_i^j}{\text{BMK}_i^{j-1}} , I_{\text{PRET}} = \frac{\text{PRICE}_i^j}{\text{PRICE}_i^{j-1}} , I_{\text{SIM}} = \frac{\text{SIM}_i^j}{\text{SIM}_i^{j-1}}
\]
The formula for calculating the attraction coefficient \( \alpha_{ij} \) for product \( i \) of firm \( j \):

\[
\alpha_{ij}^t = a_{ij}^{t-1} \cdot I_{CA}^t \cdot I_{PRICE}^t \cdot I_{BMK}^t \cdot I_{SIM}^t.
\]

\( I_{SIM}^t \)

\( S_5: \) Calculating the sum of each attraction coefficients:

\[
S = \sum_{i=1}^{n} \sum_{j=1}^{m} \alpha_{ij}^t.
\]

\( S_4: \) Calculating the final A matrix where:

\[
a_{ij} = \frac{a_{ij}}{S},
\]

\[
V_{ij} = \begin{cases} Q_{ij}, & Q_{ij} < V_P_{ij} \\ V_P_{ij}, & Q_{ij} > V_P_{ij} \end{cases}
\]

→ calculating the stocks

→ calculating the demand satisfaction degree

- Stocks

- Demand satisfaction degree

- Turnover

- Total expenditure of the firm

\[
T_{expenditures_j} = Production\ Expenditures + Wages + Other\ expenses
\]

\( S_6: \) Finding each firm’s market share using:

\[
CP_j = \sum_{i=1}^{m} a_{ij}
\]

\[\text{Output data}\]

By applying this algorithm for finding out the market share we may reveal more variables necessary for evaluating each player’s activity over a certain period. Thus we may establish:

- Potential sales for firms and products :

\[
V_P_{ij} = CP_j \cdot CT_i \quad i = 1, m, j = 1, n
\]

- Real sales grouped by firms:

\[
V_{ij} - firm\ j\ sales\ for\ product\ i;
\]

\[
CT_i - real\ demand\ for\ product\ i;
\]

\[
CA_j - turnover\ for\ firm\ j;
\]

The implementation for obtaining the global results:

```csharp
//we calculate: turnover, Profit, stock values, average market share
foreach (firm in firms)
{
    foreach (ProductInfo p in products)
    {
        vi = Sales.Sales_get(f.user_name, p.product, current_month);
        turnover = turnover + quantity * price_decision(user_name, product,
            current_month);
        demand_satisfaction += vi.demand_satisfaction;
        agerage_market_share += MarkettShare.Get(f.user_name, product,
            current_Month);
    }
    demand_satisfaction = demand_satisfaction / produse.Count();
    agerage_market_share = agerage_market_share / produse.Count();
}
```

In the simulated process, certain interdependence variables have been established:

<table>
<thead>
<tr>
<th></th>
<th>Product quality</th>
<th>Marketing budget</th>
<th>Sustainability</th>
<th>Humanitarian campaigns</th>
<th>Investments</th>
<th>Trainings</th>
<th>Product support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td></td>
</tr>
<tr>
<td>Market share</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td></td>
</tr>
</tbody>
</table>

thus, the evolution of some variables is tightly linked to the increase/decrease of other variables.
Table 3. Main variables interdependence.

<table>
<thead>
<tr>
<th>Price</th>
<th>↑</th>
<th>↑</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Additional expenditure</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Production</td>
<td>↑</td>
<td>↑</td>
</tr>
</tbody>
</table>

3. Conclusions and further work

Business games represent one of the major innovations in education, offering players the ability to develop and improve certain managerial skills regarding: the development and application of certain management politics and strategies, the scientific validation of decision-making, the organization of the managers’ tasks, creating and developing a team spirit, the systematic approach regarding the organization and its components.

The main element of this paper is represented by the market share evaluation algorithm for some firms that compete on the same market. This algorithm is the core of the application that simulates the market behaviour and sensitivity to the decisions connected to the main functions of a firm.

Because of its complexity, the development and implementation of a business game is a laborious process, taking a long time and entailing various domains like management, marketing, economic processes simulation, statistics, mathematics and computer programming. The complexity of this subject triggers a continuous development and improvement over the time, for meeting the users’ needs halfway. Thus, this first version of the game may be improved in several ways:

- developing and enhancing some firms’ functions which are only formally represented in this game, so as for the player to be able to simulate the entire activity of the firm (wages, supplying, stock management);
- adding new rules and functions;
- quasi real time playing.

The formative contribution of a managerial game depends on the following qualitative measures: to be realistic, to include large economic issues which simulate typical situations, to be interesting and have new and uncertain elements, to be similar to the economic reality in the key points while being simple enough for emphasizing key parameters.

This game was created to fulfil these qualities, but it needs to be permanently developed and adapted.

References / Biography