SOFTWARE SUPPORT OF MANAGERIAL DECISION MAKING BASED ON SYSTEM APPROACH

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Abstract— The companies' management have to deal with all that. And, once again, a question arises what approach should be taken when solving the newly emerged problems? It turns out that the current managers' problem-solving method should be based on a system approach as well as on prediction. The dynamics and indefiniteness of business environment makes a corporate management use methods based on the system approach to the business, or understanding the business as a living organism and, at the same time, take into account the growing importance of knowledge, creative human potential, and new management methods as system dynamics and other competition tools of a company of the 21st century.

The objective of this paper is creation model of Corporate Strategic Management decision-making in the conditions of food industry, on a market of a refrigeration company. Production of ice creams depends on the weather conditions during the year. The manufactured goods are of seasonal nature. As a result of great competition on the market, prices are very low and manufacturers' margins are squeezed by strong supermarket chains. Only the brand names of products and manufacturers are protected. Product differentiation is low. Product development is primarily based on copying of the most attractive product of the competition. Recipes and manufacturing processes developed by the research departments of world-wide companies are copied by all competitors. Advertising and promotion play an important role in winning customers. Companies try to launch something new every season. Preparation for each season takes place from May of the previous year.

The goal of model is to understand how the price and the sold quantity influence the sales growth rate, market share, and profit of the refrigeration company over a period of 24 months, with seasonal fluctuations in the demanded quantity on the market. One member of author´s team has practical experience from production and business at food company. For performance measurement we use Business Performance Index, i.e. a summary indicator showing the business performance; it aggregates data of three partial indicators which determine the achieved economic results of a company, i.e. the sales growth rate, market share, and profit. The following balance has been established for individual partial indicators: sales growth rate (45%), market share (35%), and profit (20%).

The model of Corporate Strategic Management used the Vensim software. Vensim is a software program for creating management modules and simulators based on the principles of modeling of dynamic systems. System dynamics is a scientific discipline which studies systems, their development and behavior over time. The possible use of the knowledge of system dynamics is based on the understanding of system behavior and structures, assessment of effects of individual alternatives, and testing of strategies. The feedback structure of the system allows recording the diagram of surfaces and flows. It uses graphic systems to describe the structure of the system. The principle is to define the surface (accumulation of changes within instant of time), artificial variables (definition by using algebraic expressions), constants (a variable became a value), a flow (changes the surface over time) and linkages among individual elements.

In this paper, we tried to apply the learned knowledge from the area of system dynamics and creation of virtual companies to the ice cream market and to show its specific aspects, such as the seasonality of production, changes in customers' preferences, as well as typical problems the production, sales, and marketing managers have to deal with.

Keywords-dynamic system, food industry, feedback structure of the system, managerial decision, vensim software, prediction model, strategic management, business performance index.

I. INTRODUCTION

The current business world, affected by the global economic recession, challenges the management and owners of companies with difficult strategic decision-making. How to respond to or even foresee changes coming from the business environment? Corporal processes are subject to turbulences and chaos. Authors Kotler and Caslione define a new economic era which is characterized by a great interconnection of national economies, conducting business transactions using information flows through the Internet, acceleration of production and distribution, which all makes it possible for companies to cut down costs. The new economy brings a higher level of risk and uncertainty to companies, on both the macroeconomic as well as the microeconomic level, which, if not coped with, turns into a chaos [5, 8]. These principles of chaos can also observed in refrigeration companies in food industry. This is because the entrepreneurship has a lot of uncertain results with deciding about quantity and price, that depending on the seasonal fluctuations of production. And,

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once again, a question arises what approach should be taken when solving the newly emerged problems? It turns out that the current managers' problem-solving method should be based on a system approach as well as on prediction [13, 14].

Vytlačil defines a company as a socio-economic system which involves a combination of natural and artificial systems. It implies that a company behaves, on the one hand, as a rational system (i.e. its mission, goals, and the related processes, structure, functions of elements and subsystems can be defined), and, on the other hand, as a natural system influenced by the interests of its employees. Socio-economic systems have certain principles in common [13, 14]:

- Openness based on understanding of behavior of open (living) systems in the context of the environment in which they exist (e.g. company's relationships with contractors, customers, etc.). General properties, common to all systems, and specific properties, typical for a particular system, may be observed in open systems. The combination of such properties gives rise the cultural code.
- Purposeful behavior, showing why particular activities and decisions within the system are carried out in a rational (selection is based on definable values), emotional (decision-making is based on emotions), or cultural (decision-making is influenced by ethical values) manner.
- Diversity meaning, that a system involves a great deal of conflicting tendencies (conflicting efforts to ensure stability as well as enforce changes). That is reflected in the plurality of structures and the structures rapidly change over time.
- Emergent properties result from mutual interaction between the system elements. They cannot be derived from the properties of the elements, but from the processes of the system. Emergent properties cannot be measured directly; only their effects are measured, e.g. financial indicators.
- Unpredictability finds expression in the fact that activities focused on obtaining certain output lead to opposing results (e.g. increase in taxes results in a decrease in companies' activity and, at the same time, laying off employees). Delay is typical for unpredictable behavior (consequences unfold in the long run), or the cause and effect may chase each other, which gives rise to a closed loop.
- The dynamics and indefiniteness of business environment makes a company management use methods which are based on a system approach to the company, or on understanding the company as a living organism and, at the same time, take into account the growing importance of knowledge, creative human potential, and new management methods as competition tools of a company of the 21st century.

The goal of paper is created model Strategic Corporate Management focuses on the simulation of strategic management of a refrigeration business in the food industry by using software Vensim. The process creation of model Strategic Corporate Management is divided into four phases: description objective reality, creation system, creation model by using Vensim, verification output of this model.

II. BASIC CHARACTERISTICS OF SYSTEM DYNAMICS AND MODELING

A. Characteristic of system dynamics

System dynamics is an approach to understanding the behavior of complex systems complex over time. It deals with internal feedback loops and time delays that affect the behavior of the entire system. What makes using system dynamics different from other approaches to studying complex systems is the use of feedback loops and stocks and flows. These elements help describe how even seemingly simple systems display baffling nonlinearity. System dynamics is a methodology and mathematical modeling technique for framing, understanding, and discussing complex issues and problems [10, 11].

The creation of a mathematical model begins by defining system elements of the system, or, quantities, from which the system consists of. We have the following system elements:

- Endogenous quantities (quantities within the system): they can change over time.
- Exogenous quantities (quantities outside the system): they influence the system and they can change over time.
- Quantities, which do not change during the study of the system development.

The loop diagram and diagram of surfaces and flows belong among basic instruments of the dynamics system. The causal loop diagram consists of variables, connected by arrows, posing the casual linkage among them. The linkage among variables can be either positive (symbol + on the arrow) or negative (symbol – on the arrow). The type of the loop results from the type and number of arrows: positive (if the action of the source is increased, the overall effect is decreased compared to the initial condition) [7].

We can deduce by Bossel [2007, p. 72] the structure of a dynamic system from the influence relationships permitted among the three types of system elements (input quantities, state variables, intermediate variables), where rates are to be represented as intermediate variables:

1. Input quantities cannot be influenced by other system elements.

2. The inputs of state variables can only be rates (intermediate variables).

3. Intermediate variables can be functions of inputs and state variables or other intermediate variables (but algebraic loops are not permitted).

4. States can only affect intermediate variables directly.

Not all intermediate variables are rates (with arrows pointing into states).

If we now try to draw a diagram using these rules, we obtain the elementary block diagram of a dynamic system (see Fig. 1).

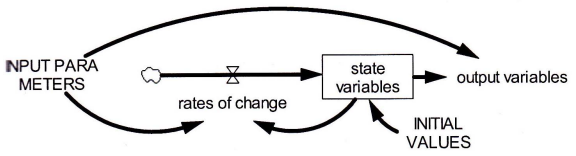

Figure 1. Elementary block diagram of a dynamic system, Bossel [2007, p. 80]

Mathematical model of the dynamics system basically consists of the differential equation system. We can display the dynamics system by using elementary block diagram, where the blocks determine vectors, and where arrows represent matrixes linkage.

The dynamics system can be understood as a set of mutually connected elements, which values develop over time and which interact. During the dynamics system modelling it is necessary to define state quantities in their dependency on time. The creation of the dynamics system modelling is a description of how the values of state quantities X are changed over time t (it is from X (t) to a value over time t + dt, it is X(t + dt), where dt is an instant time, little from the importance of individual elements point of view), Bossel [2007, p. 80].

Originally system dynamic developed in the 1950s to help corporate managers improve their understanding of industrial processes, system dynamics is currently being used throughout the public and private sector for policy analysis and design.

Nowadays support by software (e.g. Vensim, Powersim, Stell, iThnik and others) which makes it possible to create a model and, then a simulation. In your model we can use Vensim [9].

B. Specification of modeling

Bossel [2004, p. 148] specification next five steps in the modeling process:

1. "The representation of the system in the influence diagram depends on the problem setting and the model purpose. This must be specified precisely in the beginning. It determines the choice of system boundary and the way the system is analyzed by the modeler.

2. The influence diagram focuses on the influence structure of the not on the exact function of its elements. In general, it is therefore not a complete and valid description of the real system.

3. Reliable and precise information about the dynamic behavior of a system can only be produced by a simulation model which correctly represents the properties of the system elements and of their (often nonlinear) interconnections.

4. Complex simulation models can usually be broken down into submodels which can be individually developed and tested before they are linked to construct the full model. The behavior of the full model may be quite different from that of the individual submodels: The whole is not the sum of its parts but may be qualitatively different.

5. The validity of a model is defined by reference to the modeling purpose. It has four aspects: structural validity, behavioral validity, empirical validity, and application validity".

III.

IV. THE PROCESS OF CREATION MODEL STRATEGIC CORPORATE MANAGEMENT

The process creation of model Strategic Corporate Management (see Fig. 2) may be divided into four phases:

- phase: description objective reality,
- phase: creation system – define the important factor, which are important for simulation model,
- phase: creation model by using Vensim,
- phase: verification output of this model and then do the decision in real business environment.

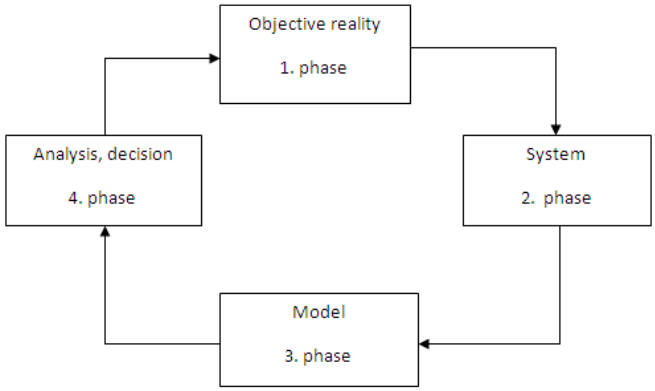

Figure 2. The process creation of model Strategic Corporate Management, Mcgarvey and Hannon [2004, p. 2]

1. Phase: description objective reality included basic characteristics of ice cream market. The weather is very important factor for range production. The manufactured goods are of seasonal nature. The basic characteristics of ice cream are great competition on the market, prices are very low, manufacturers´ margins are squeezed by strong supermarket chain and only the brand names of products and manufacturers are protected. Recipes and manufacturing processes developed by the research departments of word-wide companies are copied by all competitors and consequence is low differentiation product. Product development is primarily based on copying of the most attractive product of the competition. Advertising and promotion play an important role in winning customers. Companies tray to launch something new every

season. Preparation for each season takes place from May of the previous year.

2. Phase: creation system – define the important factor, which are important for simulation model. For understanding the Corporate Strategic Management model is need explain each variables. The following variables are used in the model:

- Maximum monthly manufacturing capacity of a refrigeration company it is 100 000 pieces of ice lollies.
- Actual use of production capacity (%) represents a proportion of the manufactured quantity set by the student company and the permitted production capacity. The interval from 75% to 80% is considered the optimal use of the production capacity.
- The required manufactured quantity of the company is monthly quantity of manufactured ice lollies, as decided by the student company, with the allowable maximum of 100 000 pieces per month.
- Stock on hand represents the remainder of the item (opening stock + production) and the decrease in stock item (pieces per month).
- Decrease in stock (in pieces) it means, if the stock quantity is lower than the sales, only the quantity in stock may be stocked out, i.e. the stock on hand cannot be less than zero.
- Outsourcing of ice lollies (in pieces) it is number of ice lollies the company has to buy elsewhere per month.
- Penalty for negative stock balance (CZK per piece) it means an amount indicating how much is to be added to the unit cost if the stock has a negative balance (i.e. a penalty amount, e.g. CZK 6 per piece, is added to the total calculated costs per piece, which is CZK 8,56 per piece). It implies that, if you establish a price of CZK 12, the loss will amount to CZK 2,56 per piece).
- Penalty for excessive stock (CZK per piece) it means concerns a penalty raising the product price if the quantity of products in stock exceeds 200 000 pieces (i.e. if there is 220 000 pieces of ice lollies in stock and the storehouse capacity is only 200 000, you have to store the surplus of 20 000 in a leased storage facility. You have to pay a penalty of CZK 2 per piece for storing such surplus (the penalty involves a sanction for excessive stock and lease of additional storage facilities and transportation to the additional facilities).
- Price per piece is established by the student company, taking into account the total cost per piece and the profit margin per unit (CZK per piece). Manufacturer's margin represents an additional charge in % of costs according to the calculation. Basically, the margin equals the amount of profit per product. The resulting price, including margin, established by the student team must range between CZK 12 and 18 per piece. The amount, or success of sales of manufactured ice lollies then ensues from the established price.
- Costs per unit (CZK) it means costs based on the initial calculation which is equal for all companies during all periods of the simulation implementation.
- Total costs (CZK per month) it means [(penalty for outsourced ice lollies multiplication outsourced ice lollies in pieces) and (penalty for excess stock multiplitaciation surplus pieces in stock) and (costs per piece based on the calculation multiplication manufactured quantity per month)].
- Number of products sold (in pieces) by the company it is amount of ice lollies sold (pieces per month)
- Demanded quantity is based on seasonal fluctuations in the demanded quantity of ice lollies (pieces per month). They will receive a three-month forecast of the demanded quantity of ice lollies (in pieces).
- Maximum capacity of the finished ice lollies storehouse is 200 000 pieces of ice lollies.
- Returns (CZK per piece) it is amount sold (in pieces) multiplication price (CZK).
- Profit is equals the remainder of the returns and costs (CZK per month).
- BPI = Business Performance Index, i.e. a summary indicator showing the business performance; it aggregates data of three partial indicators which determine the achieved economic results of a company, i.e. the sales growth rate, market share, and profit. The following balance has been established for individual partial indicators: sales growth rate (45%), market share (35%), and profit (20%).
- Number of competitors it is number of manufacturers in the food industry (only 8established virtual companies in this model).
- Total duration of simulation is 24 months.

3. Phase: creation model by using Vensim

Vensim DSS Version 5.9, developed by Ventana Systems Inc., is used for the purposes of creating a module of management simulation of market environment. We can use Vensim for develop and investigate a model for a simple production distribution system. Such systems are at the heart of most companies that make and sell products, and similar systems exist in most product or service-oriented businesses. Regardless of where you work within most companies, it is useful to understand the sometimes counterintuitive behavior that is possible in a production distribution system. As we will see, difficulties in a production-distribution system that are often attributed to external events can be caused by the internal structure of the system.

The created model (see Fig. 3) Strategic Corporate Management by Vensim focuses on the simulation of strategic

management of a refrigeration business in the food industry. The model provides users with examples of task the top management of a refrigeration company has to deal with. Thus, users learn about selected operation and management problems which fall into the scope of responsibility of production, sales, and marketing manager. Considering the application of strategic corporal management in the economic scenario, the scenario will be used by users during a simulated period totalling 24 months (two ice-cream seasons), i.e. one period represents one month of the actual lifetime of the company.

The goal of model is to understand how the price and the sold quantity influence the sales growth rate, market share, and profit of the refrigeration company over a period of 24 months, with seasonal fluctuations in the demanded quantity on the market.

The simulation is supposed to help users understand the specific aspects which are typical for the refrigeration market in the food industry, e.g. seasonality of sales, traditional tastes of customers, limited storehouse capacity during the highest demand in summer months etc., which the top management must take into account within strategic corporate management. In order to simplify the actual situation on the refrigeration marker, there will be only eight refrigeration companies on the market. For performance measurement we use Business Performance Index, i.e. a summary indicator showing the business performance; it aggregates data of three partial indicators which determine the achieved economic results of a company, i.e. the sales growth rate, market share, and profit. The following balance has been established for individual partial indicators: sales growth rate (45%), market share (35%), and profit (20%).

4. Phase: verification output of this model and then do the decision in real business environment.

On the basis of the proposed model, we can work with various scenarios of market development and analyze the performance of individual business performance to the various development market. The creation model of company from food industry was established on the real date. Allows a business entity to prepare a portfolio of product and to prepare for turbulent business environment. In the future we can create monitoring board for management using Balanced Scorecard. We must select indicator, which reflect important area of business as financial, customer, internal, human resource management, leadership, innovative and learning perspective.

V. CONCLUSION

In this turbulent time, which places great demands on the promptness and correctness of managers' decision-making, the use of knowledge of system dynamics, including software such as Vensim, Powersim, and others, seems to be an interesting tool for supporting managers' decision-making. First, it is very important to understand the system (a company, in case of managers), its development and possible behaviour over time, relationships of individual quantities, and to find mechanisms how to influence and control such quantities. The fact that system dynamics can be applied to a system of any size seems to be a great advantage.

In this paper, summarizes the creation process of modelling Strategic Corporate Management for food freezing industry/market. The first phase represented the description objective reality included basic characteristics of ice cream market. Subsequently, second phase that define the important factor which are important for simulation model and third phase creation model by using Vensim. Finally verification output of this model and then do the decision in teal business environment in fourth phase.

In conclusion, it should be useful to make other models dealing with business areas which are important for managers and which involve decision-making problems, such as the necessity to introduce product innovation to ensure smooth material flow. It would sure be beneficial for managers if such models were also created for other branches of industry, such as construction and other sectors of national economy, in the perspective of managers' problems at the micro level.

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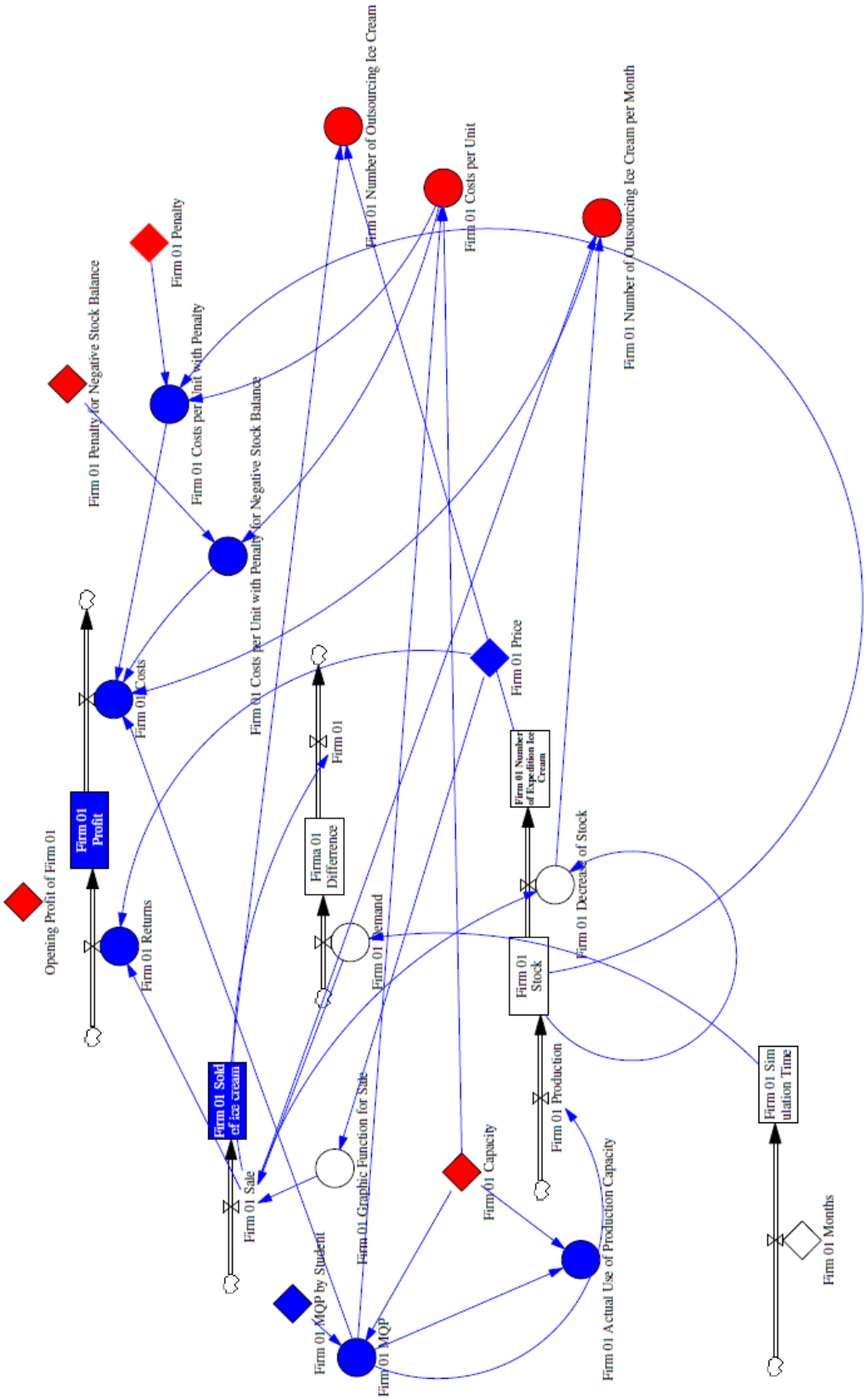

Figure 3. Model of Strategic Corporate Management