MODELING OF SUSTAINABLE DEVELOPMENT FOR COMMERCIAL ENTERPRISE APPLYING SYSTEM DYNAMICS APPROACH

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Abstract

The present paper deals with modeling of hierarchy commercial enterprise business in terms of sustainable development concept. Simulation model was created using Powersim tool that cover sales and distribution, supply and storage of products, including internal process efficiency and staff motivation. Commerce considered under the following features: dynamics; stochasticity; discrete continuity, absence of linear dependence among system parameters (nonlinear system). Among the existing imitation methods (Monte Carlo method, statistical modelling, game simulation, agent-based model, discrete modelling, models of system dynamics), we chose the concept of system dynamics created by Jay Forrester as the most suitable tool to model a system featuring the abovementioned characteristics. Stimulation in hierarchical economic systems is considered to be the main factor in managing, distribution of inventory and staff motivation. Decision support system elaborated with Powersim software simplifies analyzing of possible scenarios to develop retail network. The most common functions of stimulation are considered. The results of their individual implementations are reflected. Analysis, comparison of different scenarios and guidelines for company development are presented.

Key words: commercial enterprise, simulation, Powersim, system dynamics, sustainable development.

JEL: C53, D92, M10, Q01.

Specific set of events, factors and human intelligence level caused appearance of new global idea in 20th century named “sustainable development”. After formalization and presenting this concept by Brundtland Commission of the United Nations in 1987 it started spreading and implementing all over the world. In spite of being invented as global view and first reflected in general recommendations of ways of human being, today we have variety of models of sustainable development for different spheres and levels of our life. However, there still variety of questions that should be explored from “sustainable” point of view and developed into technologies, models and methodology that could be used in practice to support sustainable decision making.

The present paper deals with sustainable development for hierarchy commercial enterprise business and presenting model created through system dynamics approach. Modern manufacturing enterprises must collaborate with their business partners through their business process operations such as design, manufacture, distribution, and after-sales service. Robust and flexible system mechanisms are required to realize such inter-enterprises collaboration environments [17]. So business of each commercial enterprise could be considered from supply chain point of view. A supply chain system is a chain of processes from the initial raw materials to the ultimate consumption of the finished product spanning across multiple supplier-customer links [7]. Current researches on System Dynamics Modelling in supply chain management focuses on inventory decision and policy development, time compression, demand amplification, supply chain design and integration, and international supply chain management [3]. The application of System Dynamics Modelling to Supply Chain Management has its roots in Industrial Dynamics [8]. Based on the development and use of a System Dynamics simulation model, Forrester describes, analyses, and explains issues evolving around supply chain management.

System Dynamics approach was used for studies in such fields as international supply chain management [1], decision-making in stock management [16], inventory management [4], demand amplification [2], supply chain re-engineering, supply chain design [3]. A lot of researches were done in this area, but there still white spot in modelling of sustainable supply chain and the present paper aimed to fill it.

The commercial system is considered in current research under following assumptions:

1. There are 3 chains before product reaches consumer: plants, distribution center (DC), distributors.

2. DC is selling variety of fast moving consumer goods (FMCG) with expiration term 3years that do not need specific storing conditions, it's utilization in case of expiration is harmful for environment.

3. Demand of products has seasonality and it is elastic and stochastic, there are some periods when it follows normal distribution, but it is not stationary as it changes due to activities of DC, its competitors, market tendencies.
4. Transportation of goods from plants to DC and from DC to distributors is made by trucks with different levels of CO₂ emission.
5. All links of supply chain trying to minimize their inventory and grant targeted service level, there is penalty cost for out of stock (OOS) of products.
6. Effectiveness of internal processes depends on the level of a staff motivation that is increasing if it is stimulated and decreasing in case of sales increase due to work and pressure growth.
7. System activity is observed within 1 year.
   System dynamics modelling is made by usage of such instruments as Level, Flow, and Flow with Rate, Auxiliary, and Constant, which could be connected by Link or Links with Delay. So we have created blocks that simulate inventory management, ecological control, demand planning, sales stimulation, and staff motivation stimulation.
   The main indicators that took part in measurement of sustainability of the system are reflected as Levels with positive and negative flows are divided into 2 groups: internal and external. Internal indicators are technological, ecological, financial, social, and business processes sustainability measurements; external indicators are economical, ecological, and social sustainability of corporate responsibility to the market, government, people, and environment. It allows study the model as open system and analyze it's interaction between other agents. The main feature that allows calculation of stimulation’s impact is elasticity of demand and motivation.
   Built tool allows running model desired quantity of times to simulate and predict decision impact. Combined with Monte Carlo technique it gives opportunity to evaluate fruitfulness of different business decisions [10] in order to choose the most sustainable of them.

In this paper we present results of simulations for 4 situations: no stimulation is done for sales and staff motivation; linear stimulation of any sales and staff; linear stimulation with minimum sales and motivation limitation; linear stimulation with minimum sales and motivation limitation and penalty.

As the results of Monte Carlo simulation for developed system dynamics model for the enterprise under mentioned above considerations were discovered that maximum impact provides linear stimulation of any sales and staff; the most profitable is linear stimulation with minimum sales and motivation limitation; linear stimulation with minimum sales and motivation limitation and penalty has worst result as it causes negative elasticity effect.

Designed tool allows simulate enterprise activity in main business areas that provide an opportunity to assess different strategies of company development. Possibility to take into account demand stochasticity makes model closer to reality. Future research going to be focused on balanced scorecard development and integrating for described tool in order to have the system for sustainable development monitoring.

References

