Modeling the Target Architecture of an Entrepreneurial Network as a Complex System of Interaction

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Abstract. The purpose of this study is to develop a model for analyzing the effect of networking companies as a learning tool for education information systems. The article presents the results of applying the tools of system dynamics for modeling the target architecture of the main processes of interaction between participants in an enterprise network. For the first time, the feasibility of applying the system dynamics method for modeling indicators of the target architecture in the formation of a network format is substantiated. The control circuit for the involvement parameters of the assets of a new network participant is selected as the main regulator of the intensity of interaction that affects the change in the level of the company's accumulated profit, as well as its image, efficiency of use of information and logistics resources. The experiments of the system-dynamic model confirm the possibility of using it as an analytical tool in substantiating management decisions in the system of digging interaction. The feedback loops obtained during the simulation allow us to formulate the network architecture as an agent-based model, as well as to predict the necessary balance of resources for all participants in the network interaction. The growth of basic and controlled parameters is the main condition for maintaining sustainable interaction effects, forming the basis for the formation of the target architecture of the enterprise network.

Keywords: Enterprise Architecture, Architectural Approach, Information Exchange, Coalition Behavior, Logistic Interaction, Modeling Methodology, Entrepreneurial Network, Network Interaction, System Dynamics, Company Resources.

1 Introduction

The World Dynamics» of J. Forrester, which made him so famous, nevertheless, was a consistent continuation of a number of works related to intrasystem and intra-corporate planning. One of the first works in this direction was an article by J. Forrester published in 1965, in which he predicted the construction of organizations around «profit centers» resembling external business units by their interaction based on «market» prices. The analysis of intracompany networks was, in fact, one of the directions for studying the evolution of organizations, more precisely, the decentralization trends of large companies. In modern economic studies, the system dynamics method in simulation modeling has been consistently continued and developed by the Russian «System Dynamics Society», scientists N.N. Lychkina [1], D.U. Katalevsky [2], A.S. Akopov [3] and others. These studies represent a comprehensive methodology for a modern analysis of the problems of forming the strategic architecture and corporate dynamics of an enterprise, effective inventory management in logistics systems, as well as the ability to predict the nature and structure of regional systems, identify imbalances in the development of countries and territories, balanced management in the architecture of interaction processes. The presented results, as a rule, do not consider the system as a black box, and the analysis of the structure and its previous states becomes the basis for the development of control actions, interaction rules that can maintain stability and balance, as well as the specified parameters of the system's functioning as the target states of its architecture [4]. The latter is a fixed characteristic of the system, capable of ensuring the efficiency of the organization of the processes that are realized in it in dynamics - the processes of interaction.

2 Theoretical Background

The architectural approach, which logically continues the system and engineering approach, involves in this case a structural analysis of the system based on the combination of SNA-methodology (SNA - Social Network Analysis) and system-dynamic simulation of J. Forrester. Thus, the architecture of relations in such a system as in a complex system of interaction is one of the mechanisms for coordinating the actions of economic agents, participants in the interaction, which has its own characteristics that distinguish it from other mechanisms for coordinating relations in the system. At present, the study of the network interaction of companies is clearly interdisciplinary in nature [5, 6]. Given that the behavior of the system is formed from the interaction of many participants, each of which has certain characteristics of behavior, an attempt to predict the results of interaction in a social system becomes a difficult but feasible task, provided that modern methods of system-dynamic simulation are applied.

Currently, system dynamics is one of the areas of simulation along with discrete event, agent modeling fnd others [7-11]. The concept of «system» is important in understanding the essence of systemic dynamics, which states that the world around us is a combination of complex social systems with non-linear behavior and often unobvious dynamics of interaction.

In accordance with the objectives of this study, we will conduct a simulation of intercompany interaction between state-owned enterprises, each of which, pursuing the goal of maximizing profits, nevertheless, as a structural element of a larger organizational structure, should not reduce its effectiveness when it is included in the intercompany cooperation system new participants in the interaction [12, 13]. Research has shown that entrepreneurs also play a vital role in adoption of government services [14, 15]. Simulation procedures provide two decision-making paths based on the results of forecasting the values of the target architecture of the inter-organizational network: strategy 1 (the basic format in which a new participant does not join the network) and strategy 2 (justifies the inclusion of a new interaction participant in the network). The target architecture of the entrepreneurial network is determined on the basis of the developed system-dynamic adaptive model (formula 1-5) of the analysis of the effect of networkization companies, as a result of predicting the economic efficiency of the interaction indicators (levels) of all business units as elements of a complex system.

The equations for predicting the values of the main levels of the system-dynamic simulation model are given below.

The company's image, information exchange and logistics resources are defined as relative indicators (from 1 to 10 dimensionless units), a comparison of which determines the proportionality of the contribution of a new participant in the interaction to the existing assets of company 1. The dynamics of the image of company 1 is described by the formula:

$$L1(t) = \int_{t_0}^{t_k} F1(\tau)d\tau + L1(t_0),\ t = \underline{t_0..t_k}, \quad (1)$$

where *L1(t)* is the current image of the company at the time *t*;

t_0– initial moment of simulation;

t_k – final moment of modeling;

F1() is the intensity of the change in the company's image at time τ.

The initial value of the company image (which also corresponds to the model parameter in the absence of the network interaction) *L1t0=1*.

The level of the information exchange in the main sources of information of financial statements [8]:

$$L2(t) = \int_{t_0}^{t_k} F2(\tau)d\tau + L2(t_0),\ t = \underline{t_0..t_k}, \quad (2)$$

where *L2(t)* is the current level of the information exchange in the main sources of the information at the time *t*.

F2() is the change in the intensity of the information exchange at the time τ.

The initial value of the intensity of the information exchange (which also corresponds to the model parameter in the absence of the network interaction) *L2t0=1*.

The level aggregating changes of company resources in the system of the logistic interaction:

$$L3(t) = \int_{t_0}^{t_k} F3(\tau)d\tau + L3(t_0),\ t = \underline{t_0..t_k}, \quad (3)$$

where *L3(t)* is the current value of the level that aggregates changes in the resources of the logistic interaction at the time *t*.

F3() is the rate (intensity) of the exchange of resources of the logistic interaction of companies at the time τ.

The initial value of the logistic interaction resources (which also corresponds to the model parameter in the absence of the network interaction) *L3t0=1*.

The level of growth / decrease in additional sales volumes:

$$L4(t) = \int_{t_0}^{t_k} F4(\tau)d\tau + L4(t_0) = \int_{t_0}^{t} (D1(\tau) - D2(\tau))d\tau + L4(t_0),$$

$$t = \underline{t_0..t_k}, \tag{4}$$

where *L4(t)* is the accumulated value of the level of additional sales volumes (achieved by the company only if it enters into network interaction with other participants), at the time *t*;

D1 (τ) is the monthly income of a company that has entered into network interaction;

D2 (τ) is the monthly income of a company that does not enter into network interaction;

F4() is the current (monthly) additional sales volume at time τ, is determined as follows: *F4=D1-D2*.

The initial value of the level of the additional volume of sales of goods (which also corresponds to the parameter of the model in the absence of the network interaction) *L4t0=0*.

The effect of creating a supply-implementation value chain (cost-cutting effect):

$$L5(t) = \int_{t_0}^{t_k} F5(\tau)d\tau + L5(t_0) = \int_{t_0}^{t} (D1(\tau) * (UR2(\tau) - UR1(\tau)))d\tau + L5(t_0),\ t = \underline{t_0..t_k}, \tag{5}$$

where *L5(t)* is the accumulated value of cost reduction (achieved by the company only if it enters into network interaction), at time *t*;

UR1(τ) is unit costs (the sum of expenses per 1 ruble of revenues) of the company that entered into network interaction;

UR2(τ) is unit costs (the sum of expenses per 1 ruble of revenues) of the company that does not enter into network interaction;

The initial value is $L5(t_0) = 0$

In Fig. 1 is a diagram of a simulation model of the target architecture of the studied business network. The main experiments with the model make it possible to determine the change in key performance indicators for two companies - participants in the network interaction, taking into account the influence of the factor «Interaction intensity», as the constants for controlling the convergence of companies according to target interaction indicators.

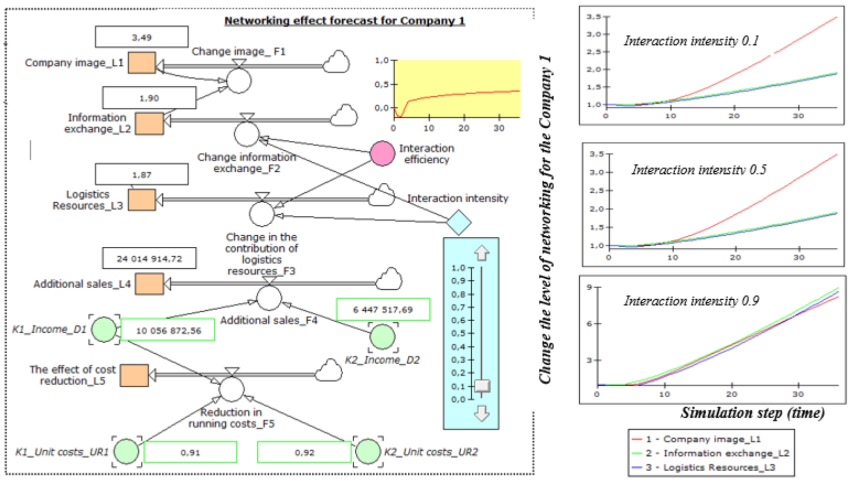

Fig. 1. Basic structural elements and simulation results of a system-dynamic model for analyzing the effect of networking companies.

3 Methodology and results

As shown in the graph in fig. 1, the dynamics of the Interaction efficiency indicator is such that in the first 3 months at the stage of involving the resources of Company 1 in the network interaction, they still do not bring returns, which negatively affect the performance of the company (decrease in purchases and sales, increase in unit costs) The subsequent increase in the interaction efficiency indicator, which is set at 0.36, has a damping tendency, since the distribution of resources within the network reaches an optimal equilibrium state, and the network acquires a new equilibrium state (taking into account the contribution of the assets of the new participating company). Also, this decaying trend may be caused by conflicting behavior of participants or a low degree of market loyalty, which does not welcome the emergence of a new organizational form [7]. The study of these aspects of networking is the basis for further research.

4 Conclusion

The testing of the presented system-dynamic model confirms the possibility of using it as an analytical tool in substantiating managerial decisions in the system of the digging interaction. Interaction: coalition, cooperative, intercompany, market or project needs to be developed in such a way that the economic efficiency of neither the company that accepts the resources and assets nor the one that provides them is reduced. The system dynamics method and feedback loops obtained during the simulation allow us to optimize the network architecture, as well as the necessary balance of resources of all participants in network interaction. The growth of basic and controlled parameters is the main condition for maintaining sustainable interaction effects, forming the basis for the formation of the target architecture of the enterprise network.

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