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System modeling and control of organization business processes by use of balanced scorecard and system dynamics*

by

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Abstract: Developing an effective business strategy ought to be based on the aspects of rationality, not only with the roots of present time, but also with the past and characteristics acquired in previous competitive episodes that may form the context for future ones. Thus, in analyzing the possibility of supporting decision-making process, one should take into account the essential properties of economic entities (objects), such as their complexity, dynamics and nonlinearity. Within this perspective, in order to model the dynamic behavior, system dynamics approach has been used in the work here reported. This technique complements the popular management approach of balance scorecard, providing the multidimensional view of an enterprise and expressing the interrelations among different processes in it.

Keywords: system dynamics, control, balanced scorecard, decision making, simulation, strategy

1. Introduction

The traditional model of an integrated value chain has been considered over the past decades as linear and sequential, with value creation seen primarily through the perspective of cost adding (see Normann and Ramirez, 1993). Intensified capital flows, economic deregulation, rapid technological changes and innovations, information technology, as well as general globalization have triggered decomposition of the traditional value chain. Further, the decreasing number of companies in branches of industries is closely associated with the increase of economic strength and dominant position of the largest companies. Quantitative studies show that the company's viability depends in 46% on itself, in 16%

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on the factors proper for a given branch, and in 38% on external factors, acting from the outside of the company and the branch (see Cyrson, 2001). Hence, a company operating in such circumstances always faces the necessity of decision making with respect to what is the variant of proceeding that maximizes profits in a situation where one is compelled to compete with a definite number of like-minded rivals in an uncertain environment. Net profit of the company depends not only on its decision, but also on actions of its competitors and the surrounding environment. Managers, therefore, must assess the situation not only from their own points of view, but also from the perspective of competitors, hence it becomes important to carry out constant observation, monitoring and modeling – with adequate reactions, if necessary (Musiał and Banaś, 2016). Of importance are also the actions of the national regulator, especially with respect to establishing the strategic directions. Historian Martti Häikiö (2002, p. 103) says that the phenomenon of development (Finland, Nokia) "(...) should rather be examined from the perspective of the interaction between the new inventions and government regulations. The explanation of a new stage in the economic development is liberalization of competitiveness, including deregulation, which occurred simultaneously with an unprecedented transition in quantum technology (transition to digital). These two phenomena have occurred at the same time, it does not mean however, that they were interrelated (...) ".

In recent years, great importance has also been gained by a completely new phenomenon of creating new value chain with the help of digital platforms and Big Data. According to Van Alstyne, Parker and Choudary (2016), competition can arise from the side of seemingly unrelated industries, and can even occur on the same platform, what changes completely the competitive landscape of companies. Digital platforms now connect consumers and producers, e.g. Amazon, Uber, Airbnb, Alibaba, etc., which also requires a completely different approach to strategy. A key advantage of the platform is the external community of members. The emphasis shifts from controlling the resources onto their co-ordination and the creation of "network effects" that enhance the value for all participants in the ecosystem of the company. A portrayal of the above is provided, e.g., by the situation, when the iPhone came into the market in 2007. By 2015 the profits from its sales accounted for 92% of global profits in mobile phones, whilst the majority of giants that once ruled the telecommunication market have not received almost any profit at all (like, for instance, the already mentioned Nokia). In summary, the entirety of the factors mentioned creates a turbulent and volatile environment – the ecosystem of an enterprise

2. Ecosystem of an enterprise

The environment, in which we live and work, becomes steadily increasingly complex. As mentioned in the Introduction, decomposition of the traditional value chain in companies, but most of all – technological innovation, globalization, regulations, ubiquity of information, the Internet – all of these exert definite and intensive impacts on the ecosystem of a company. Process feedbacks, nonlinear relationships between variables, time-delays, etc. are quite natural features of complex systems and, when cognized, constitute important sources of information, both in the process of building a model of the company and in analyzing its behavior. Moreover, correlation between episodes at present time, in the past and in the future, in the activities, behavior and human decision-making points, as well, towards the existence of a deterministic component as coupled with the generally stochastic nature of the enterprise ecosystem. M. E. Porter (1990) emphasizes that the evolution of industries is not only dynamic, but also path dependent: the corporate (and country-level) capabilities, acquired during previous competitive episodes, shape the context for future competitive battles. Moreover, accumulation of competitive advantage can be self-reinforcing, suggesting at least one way in which the behavior of industries is non-linear. In line with the above, by engaging dynamic approach in the respective analyses, an enterprise can be considered (symbolically) as an economic system, characterized by events with its own dynamics each. Over time and space, in such a system, multiple changes take place (driven generically by people, and by internal and external processes/forces). This leads to an observation of many complex phenomena (derived from, and characterized by such dynamic changes), being immersed into trends/patterns, discontinuous changes. The respective considerations should capture, therefore, the organization and its operating environment, taking into account actual characteristics of its native features, which are not: linear, static, or being in equilibrium state, with, additionally, the actual processes at the level of enterprise being inherently characterized by delays. Appropriate identification of the thus arising system may be important for the analysis and prediction of the development trends regarding the studied phenomena and can effectively support decision making.

3. Balanced Scorecard perspectives of an enterprise

When analyzing a company, as an economic system – with definite simplifications, assumed for the sake of analysis – it is easy to note that such a system can be seen as collection of different structures (human resources, financial, informational, etc.) and processes (key processes, related the client, product, delivery, management and support). These structures and processes can be bundled in the perspective of the so-called Balanced Scorecard (see Kaplan and Norton, 1992), with their mutual relations. This, in turn, leads to a kind of phenomena, having cumulative effects, for a number of events, occurring in different subspaces of the company in time and physical space. Due to the complexity of the resulting object system, the effective methods of analysis and evaluation of its behavior, which would be meant to support decisions making process and to building of strategies, should take into account the actual composite nature of the economic object – the company.

An attempt to create even a basic, but possibly comprehensive organizational model, requires an understanding of the ”principle of action” of business processes, internal and external interactions/environmental influences, etc., which also shall be executed through various functional perspectives of the engaged staff. Such an attempt should also be based on integration of mental models of the involved staff (their understanding of the issues, their interpretations and judgments), together with the general thinking and system modeling, which, while simplifying, out of necessity, ought to reflect the transition from models perceived as linear, with events evaluated in the short term, into "multi-dimensionality" and longer time horizons. Such a transition with the use of the available knowledge and methodologies can be obtained by simultaneous application of the methods for "soft" and "hard" system modeling, e.g. the soft operational research in conjunction with system dynamics techniques. Not without significance is that this instrument may also be useful in the multi-faceted monitoring (and benchmarking) with elaboration of possible solutions (controls) to achieve the desired (selected) performance regarding business activity, understood not only in terms of purely economic values - but also in the perspectives of the customer, product (or service), delivery and implementation, internal processes/management and support. It would involve forming of the shorter or longer horizon prognoses and predictions, and developing the actions/scenarios (growth/stagnation/fall) for the company – depending on the characteristics and conditions of the operating organization environment, the respective ecosystem.

4. Methodology

In terms of complex systems modeling (regarding the entire study, conducted by the authors of this paper), use will be made of the conceptually coupled standard methods, both in terms of a static image (using the Balanced Scorecard, BSC, for strategy implementation) and the application of the System Dynamics, SD, technique as a method for simulating the behavior of an enterprise over time.

4.1. Use of standard models and tools for strategy building

Van Assen, Van den Berg and Pietersma (2009) describe at length the main contemporary tools, practices, and models, pertinent to the domain at hand. These models are used for the analysis and strategic planning of the company, with the aim of answering the strategic questions (e.g. the five Porter's forces); the organizational business processes, resources and people (e.g. the Tactical models); as well as implementing best practices (Balanced Scorecard). Analysis of the main contemporary tools, practices and models tends to suggest that, at best, they are just a new way of looking at a situation that will cause the change. Management models and theories contribute – as well – to the achievement of transparency in economic activities by reducing the level of complexity and uncertainty, but their predictive value is limited: modeling at time "t" returns results, which are inherently related to the same time "t"; modeling at time "t + 1" returns the results based on the situation at "t + 1", etc. , whilst in the truly dynamic approach, modeling of value (input) at the time "t" has its impact on the value of output at a number of subsequent intervals "t + n", what means: the output value depends on the input value in the past and this reflects the actual and changing conditions prevailing in the enterprise ecosystem.

4.2. Dynamic models

Thus, in the present work, it is assumed that a company is a dynamic, nonlinear, interdependent economic object with inherent structures of both randomness and determinism - as the characteristics describing the essential traits of a company (randomness and determinism coexist). It is also assumed that there is some control of the dynamics involved, which influences the behavior of the object and is associated with the support for management processes. In modelling of internally interdependent and dynamic objects in the economy, one has to refer to both the basics of dynamic nonlinear systems and to the special phenomena, which arise in or are pertinent to such systems: aperiodicity, limitation, causality, sensitivity to change, many of them deemed to entail the chaotic behavior of the otherwise deterministic systems (see, e.g., for an insight into the behavior of such systems, Abraham-Frois, 1998).

4.2.1 System Dynamics

In this study we deal with construction of a model, representing a company, where the measured and monitored output parameters (see Fig. 1) form the possibly complete range of the company perspectives: financial, customer, operational, learning, and growth (in close relation to the expression of the BSC, see Akkermans and Van Oorschot, 2002). As a result of such data analysis, the simulations are carried out of enterprise behavior in the shorter and longer term, and adjustments are developed to the strategy towards establishing new actions – all depending on the behavior of the enterprise ecosystem and external conditions.

Within such an approach, the Balanced Scorecard (BSC) helps to tailor the strategy to the changing environment. Instead of the well-known rigid plan development, it introduces flexible framework and continuously reviews the implementation of objectives (it detects, in particular, the targets that cannot be realized). In connection with System Dynamics it can serve as meaningful approach for developing the strategy, its testing, implementation and control for enterprise (see, for instance, Linard and Yoon, 2000; Barnabe, 2011; Bianchi and Montemaggiore, 2006; Fretheim, 2013).

System Dynamics (SD) constitutes an attempt to understand and to represent the dynamic behavior of complex systems, applied for the purpose of modeling of dynamics, with consideration of non-linearity. SD uses the concepts of stocks, flows, internal feedback loops, and time-delays. It is a methodology and mathematical modeling technique, which is applicable in problems arising in complex social, management, economic, ecological, and strategic systems, characterized by interdependence, mutual interaction, information feedback, and

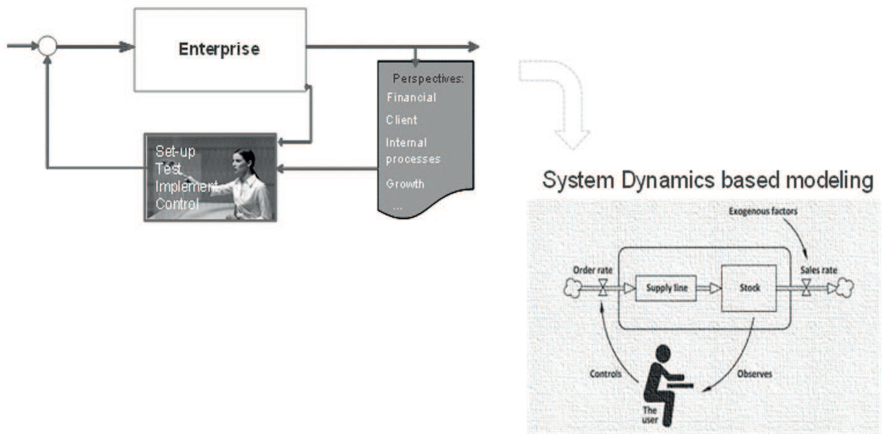

Figure 1. The enterprise, as a system of measurement of information (BSC), and its control - represented in terms of System Dynamics

cause–effect relations (see Homer, 2012). Mathematically, the basic structure of a formal model of System Dynamics in the computing simulations is realized by the first order differential equations (or integrals). Historically, System Dynamics was developed by Jay W. Forrester (1961). The original work of Forrester had emphasized the approach to modeling of systems as reflecting the continuous processes, however, nowadays, an increasing practical applicability is associated with the use of System Dynamics for capturing of discrete systems. The leading software applications for modeling and simulation according to the System Dynamics paradigm are: Vensim (Ventana Systems, www.vensim.com), iThink, Stella (iSee Systems, www.iseesystems.com), PowerSim (www.powersim.com), as well as Anylogic North America, LLC (Anylogic, www.anylogic.com). For the computational purposes, in the study, reported in this paper, the Stella software of iSee Systems was made use of, complemented by the procedures implemented in Python and R language.

4.2.2 A dynamical model of an enterprise

The model stems, in its content, from the BSC approach and therefore consists of four modules that represent four BSC perspectives (Customer, Internal Processes, Financial, Learning and Growth). All the variables are considered to be the functions of time t (Fig. 2). The model itself has been designed to reflect the real case, based on one of Polish High-Tech companies (a company listed at GPW, the Warsaw stock exchange).

Equations and coefficients were set up based on authors' own elaboration and the working experience (in particular, the functions approximating some of the variables). Supportive sources used with this respect are: Managed Services telecommunication sector / Gartner's Business Value Model methodology (see, for instance, G00249947, 2015).

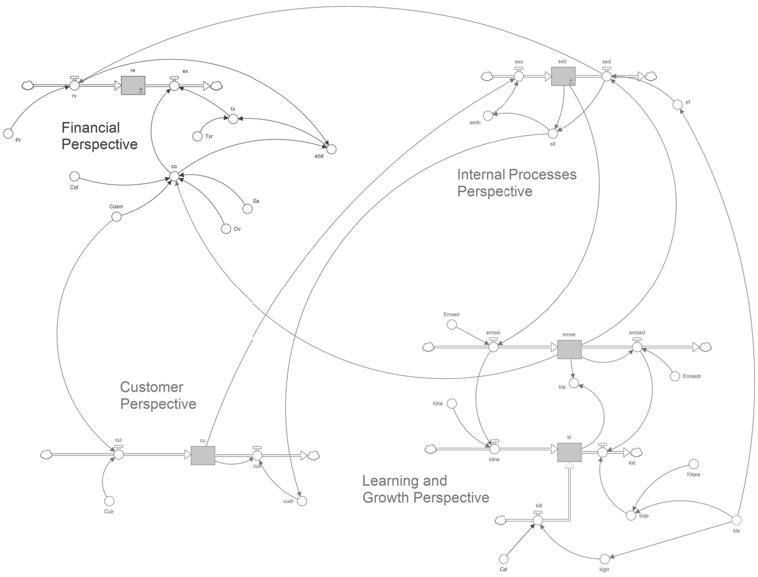

Figure 2. An enterprise in the BSC perspective and its control, expressed in the System Dynamics environment – an overall view. Source: own elaboration

In what follows, we shall describe the particular elements and relations of the model developed.

Thus, the number of customers *cu* (Fig. 3) is the main variable in the component of the model, dedicated to the Customer Perspective. This number is calculated on the basis of the differential equation of the form

$$\frac{d[cu(t)]}{dt} = cui(t) - cud(t), \tag{1}$$

where

cui – represents the increase of the number of customers, i.e. the (marginal) number of new customers that are acquired by the sales & marketing operations;

cud – represents the decrease of the number of customers, that is, the (marginal) number of customers that withdraw due to various reasons.

The increase of the number of customers is a product of the parameter *Cuir* – the rate of potential increase in the number of customers, and the value of *Cosm* – the spending for sales & marketing (the latter quantity is currently chosen as constant, but it generally can be variable):

$$cui(t) = Cuir * Cosm. \tag{2}$$

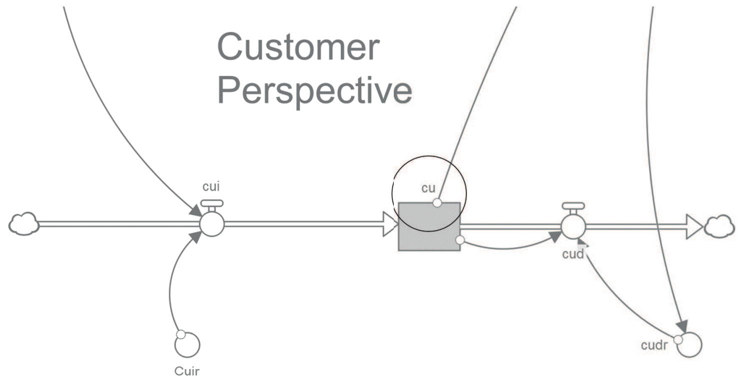

Figure 3. The Customer Perspective in the System Dynamics environment. Source: own elaboration

The decrease in the number of customers depends on the current number of customers:

$$cud(t) = cudr(t)^{*}cu(t) \tag{3}$$

where *cudr* – the customer number decrease rate, is a linear function of service, having the lead time (*slt*):

$$cudr(t) = 0.0483 * slt(t) + 0.0172. \tag{4}$$

The value of the service lead time (*slt*) is transmitted from the Internal Processes perspective (Fig. 4).

The main equation is in this latter perspective is

$$\frac{d[seb(t)]}{dt} = seo(t) - sed(t), \tag{5}$$

where: *seb* – service backlog; *seo* – service ordered by customers, *sed* – delivered service. These two latter quantities are calculated according to:

$$seo(t) = sedc(slt) * cu(t), \tag{6}$$

and the number of services demanded by the customer, *sedc*, is approximated by the equation

$$sedc(st) = -0.000003 * slt^3 + 0.0008 * slt^2 - 0.0879 * slt + 4.3013. \tag{7}$$

The quantity of the delivered service, *sed*, depends on the work efficiency and the number of service employees *emse*:

$$sed(t) = ef(kl) * emse(t). \tag{8}$$

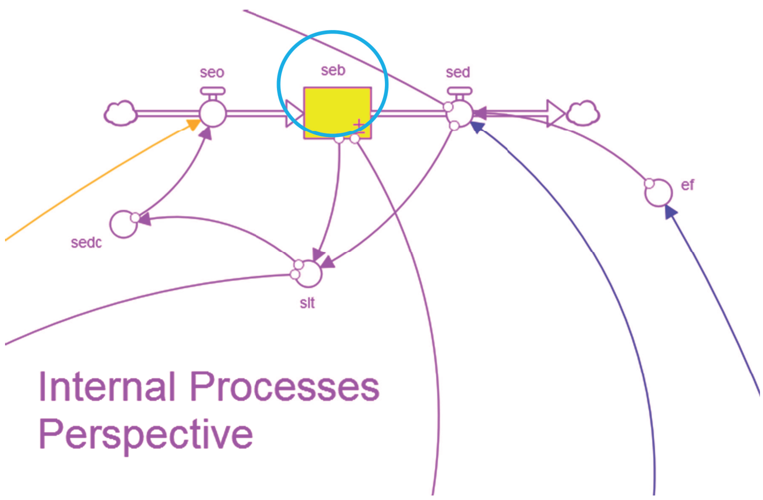

Figure 4. The Internal Processes Perspective in the System Dynamics environment. Source: own elaboration

Efficiency, in turn, is approximated by the following equation:

$$ef(kla) = -0.0001 * kla^2 + 0.0176 * kla^2 + 0.4749 * kla + 49.315. \quad (9)$$

Now, the Financial Perspective, which is illustrated here in Fig. 5, contains also one differential equation that governs the dynamics of the retained revenues, re ($rv(t)$, being the revenues, and $ex(t)$ being the expenses in the respective formula, which is provided below:

$$\frac{d[re(t)]}{dt} = rv(t) - ex(t). \quad (10)$$

Revenues are calculated as the product of the unit price parameter Pr and the number of delivered units of service, $sed(t)$:

$$rv(t) = Pr * sed(t). \quad (11)$$

The number of delivered units of service is, in turn, proportional to the average employee efficiency (ef) and the number of service employees, $emse$:

$$sed(t) = ef(kl) * emse(t), \quad (12)$$

where kla is the average skill and knowledge level of a service employee

$$kla(t) = \frac{kl(t)}{emse(t)}, \quad (13)$$

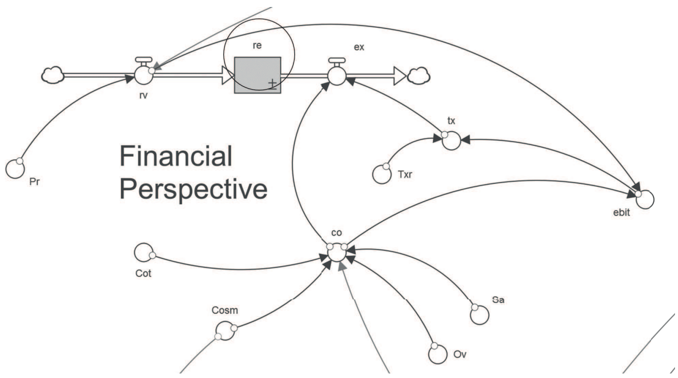

Figure 5. Financial Perspective in System Dynamics environment. Source: authors own study

and $kl(t)$ is total knowledge of service employees.

Expenses consist of the basic costs (co) and income tax (tx)

$$ex(t) = co(t) + tx(t), \tag{14}$$

where it is understood that costs comprise the direct personal costs, augmented by the overhead (Ov) and two other main positions: costs of sales & marketing ($Cosm$) and costs of professional trainings (Cot). These latter two positions can be variable, but at the moment they are assumed to be fixed. In the following equation, Sa denotes the average salary of a service employee

$$co(t) = emse(t) * Sa * (1 + Ov) + Cosm + Cot. \tag{15}$$

Tax is calculated from the equation

$$tx(t) = Txr * ebit(t), \tag{16}$$

where $ebit$ is given by

$$ebit(t) = rv(t) - co(t). \tag{17}$$

The number of service employees $emse$ and the total knowledge of service employees kl are the variables that belong to the Learning & Growth Perspective (Fig. 6). The differential equation for calculating the values of $emse$ is

$$\frac{d[emse(t)]}{dt} = emsei(t) - emsed(t), \tag{18}$$

where $emsei$ is the increase in the number of employees in service and it is proportional to service backlog (seb):

$$emsei(t) = Emseir * seb(t), \tag{19}$$

where, in turn, the constant *Emseir* represents the rate of this increase; and *emsed* is the decrease in the number of employees in service, which is proportional to the current level of employment, with the rate expressed by *Emsedr*:

$$emsed(t) = Emsedr * emse(t). \tag{20}$$

The second differential equation in the Learning & Growth Perspective (Fig. 6) describes the dynamics of knowledge (*kl*):

$$\frac{d[kl(t)]}{dt} = kline(t) + klit(t) - kld(t). \tag{21}$$

In the above equation, (21), *kline* is the knowledge of a new employee and it is proportional to the number of new employees (increase in the number of employees). The parameter *Klne* expresses the average knowledge of a new employee

$$kline(t) = Klne * emsei(t). \tag{22}$$

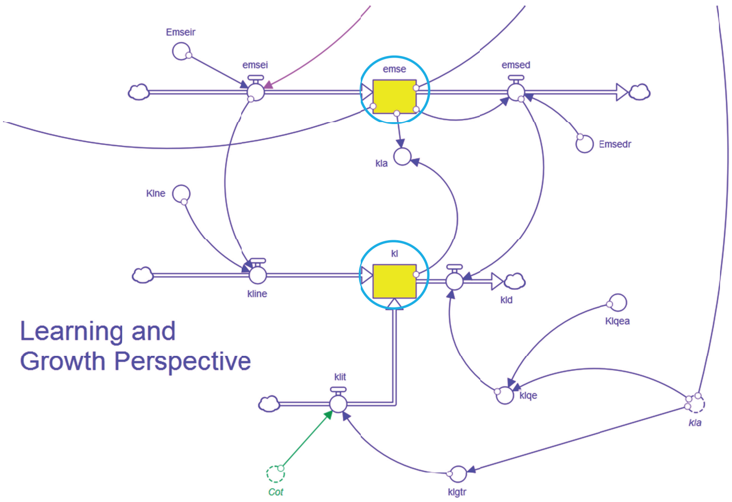

Figure 6. The Learning and Growth Perspective in the System Dynamics environment. Source: own elaboration

The variable *klit* corresponds to a measure of knowledge increase, gained owing to trainings:

$$klit(t) = Cot * klgtr(kla). \tag{23}$$

It is proportional to the costs of trainings and to the knowledge gaining rate *klgtr*, which is approximated by the following equation:

$$klgtr(kla) = -0.0007 * kla^2 + 0.0277 * kla + 8.6231. \tag{24}$$

The last term, *kld*, which appears in eq. (21), is responsible for the loss of knowledge, which is assumed to be proportional to the number of employees that quit:

$$kld(t) = klqe * emsed(t). \tag{25}$$

The variable *klqe*, which appears in equation (25), denotes the average knowledge, ascribed to the leaving employee, this particular average knowledge being, in turn, proportional to the average knowledge of an employee (*kla*):

$$klqe(kla) = Klqea * kla, \tag{26}$$

where *Klqea* is the ratio of the average knowledge of the leaving employee to the average knowledge of an employee.

4.2.3 Simulations performed with the model

For purposes of simulating the behavior of an enterprise in the light of BSC perspectives, an economic object has been selected, namely an approximately medium size enterprise, according to EU regulations (EU, 2008). This particular company is listed at Warsaw Stock Exchange. The company belongs among the premium managed services segment of the telecommunication branch. Mapping was performed of the economic results (based on the financial report of the company) into the System Dynamics–BSC model. Simulations of the company behavior were based on the lean version of the model here specified, built with the help of Stella software application. The results were obtained from a series of computing runs – simultaneously in the perspectives of the customer, financial, internal processes, and learning &growth areas for the period of 24 months. While a longer horizon of simulation is also feasible, say, of 120 months, but it would not be adequate to the lean model developed and tested in the course of the study, which is reported in this paper – due to the dynamics of the environment of the telecommunication branch and the capacity to observe adequate results. The Runge-Kutta method was used for solving the differential equations. Mapping of the internal interactions between areas of BSC perspectives helped to determine both:

i. the performance for achieving the "decent" results (Figs. 7-10), based on real input parameters in the perspectives of BSC

and

ii. the critical values of the model leading to high sensitivity to initial conditions and oscillations (Figs. 11-15).

Such an approach ultimately provides a supportive guidance for decision making, and helps to build the future strategy of the enterprise.

Regarding the second group of simulations, (ii), in those, which are illustrated in Figs. 11 through 14, only one of the selected parameters was changed against the background of the original values adopted, which were derived from the financial report of the company. Then, finally, in the single simulation, illustrated in Fig. 15, change of two parameters took place.

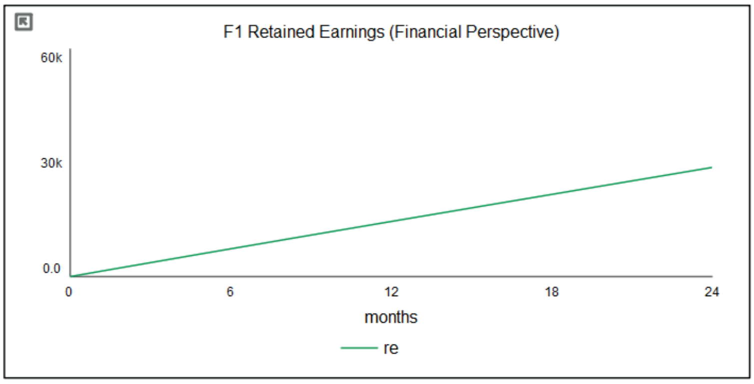

Figure 7. The “decent” results (i): the Retained Earnings (Financial Perspective). Source: own elaboration

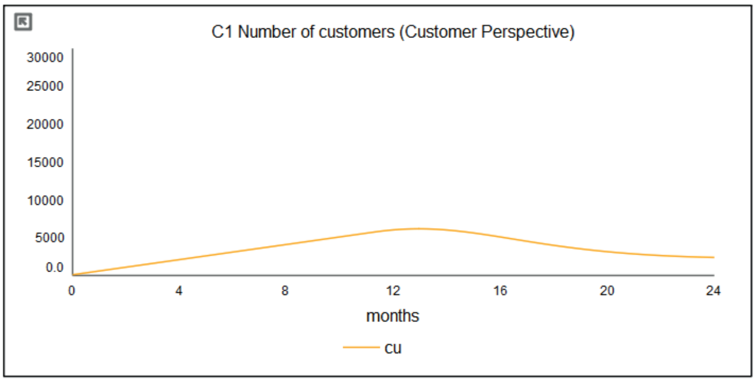

Figure 8. The “decent” results (i): the Number of customers (Customer Perspective). Source: own elaboration

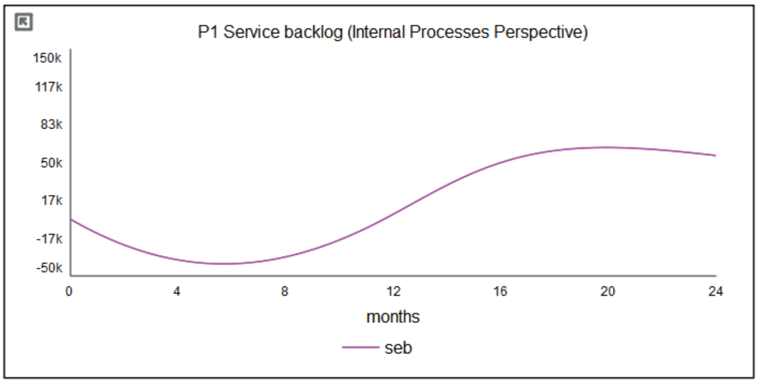

Figure 9. The “decent” results (i): the Service backlog (Internal Processes Perspective). Source: own elaboration

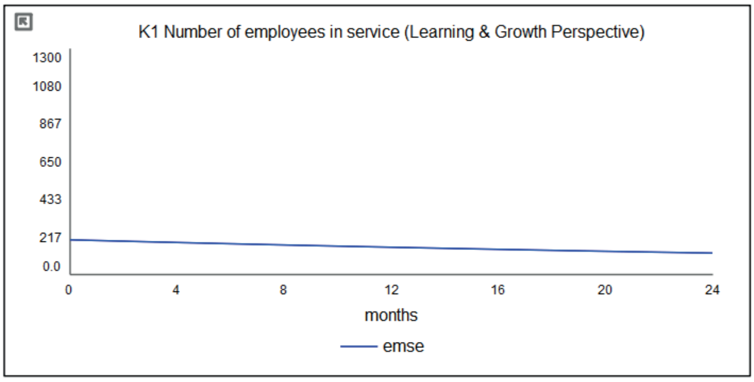

Figure 10. The “decent” results (i): the Number of employees in service (Learning & Growth Perspective). Source: own elaboration

The following observations can be formulated on the basis of the results obtained from these and other simulations, based on the model presented here:

By increasing *Cuir* (Fig. 11), the variable intended to measure the effectiveness of sales and marketing spending in relation to the number of new customers gained, i.e. as per kEur spent – from 10 to 50 – an improvement has been observed as to the number of customers in the first year and the backlog efficiency, what contributes to better utilization of the staff, but with a tendency of the staff to leave the company in a longer run.

With the decrease of *Cosm* (costs of sales and marketing), see Fig. 12, from 50 to 10 kEur, a cumulative decline has been observed in the number of customers, and a decrease in the backlog efficiency, this contributing, altogether, to a worse utilization of the staff and to staff leaving the company.

When increasing *Cosm* (Fig. 13), i.e. the costs of sales and marketing - from 50 to 100 kEur, it has been observed that an overall decline in the number of customers takes place (although the first half of year was excellent), along with the increase in the numbers of staff leaving, caused by service backlog.

Regarding the values of *Emseir* (Fig. 14), meaning, actually, a slight increase of the headcount (from 0.0 to 0.01), a sensitive dependence on initial conditions has been detected, resulting in oscillations in the Service backlog with simultaneous positive effects on Retained Earnings and Customers.

Note: *Emsir* is the quantity (fraction), being not an integer (e.g., 0.01), above the replacement of attrition*), by which it is possible to either increase or decrease headcount in a given month. The hiring fraction of 0.0 (zero) means no net increase in headcount will occur.

*) attrition = a measure (rate), at which employees voluntarily leave the company. The (rate of) attrition can also be referred to as the employee turnover rate or the "churn" rate. If the company has a high attrition rate, it may cost a significant amount of money to continually replace employees (with maintenance of skill and knowledge). Furthermore, customers may perceive a drop in the value of product or service due to a diminished work force or lack of morale or motivation in remaining (and "replacement") employees. Such damage may further impact company's bottom line.

Simultaneously with a slight increase in *Emseir* (corresponding to the experiment, illustrated in Fig. 14), the *Cuir* parameter has been increased, too (corresponding to the experiment of Fig. 11), what, for this simultaneous change, resulted in the strengthening of the company performance, although leading into not desired over-boosting (results of simulation shown in Fig. 15).

5. Conclusions and further work

In the business activities, conducted by each and every company, one of important imperatives of success is to achieve competitive advantage, with the desired strategy being developed as the essential precondition. It becomes, therefore, imminent not only to build on the standard approaches, immersed in the traditional advantages, such as the cost leadership, differentiation, or concentration,

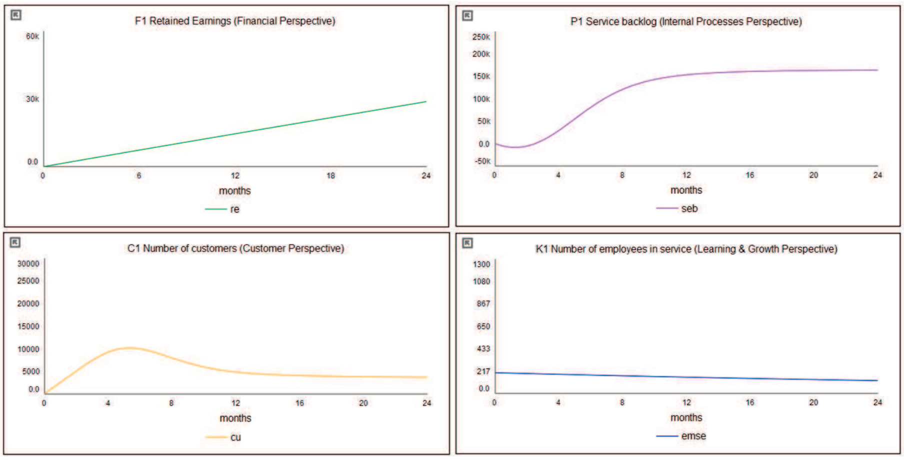

Figure 11. The critical results – increase in *Cuir*

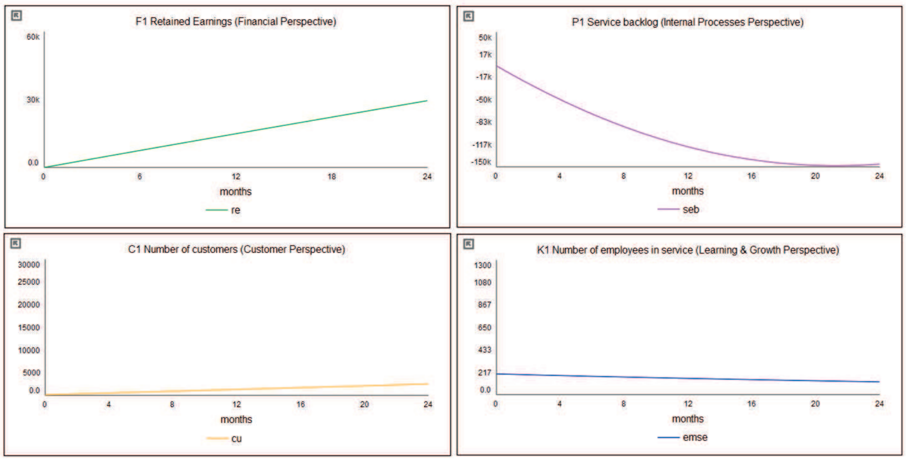

Figure 12. The critical results – decrease in *Cosm*

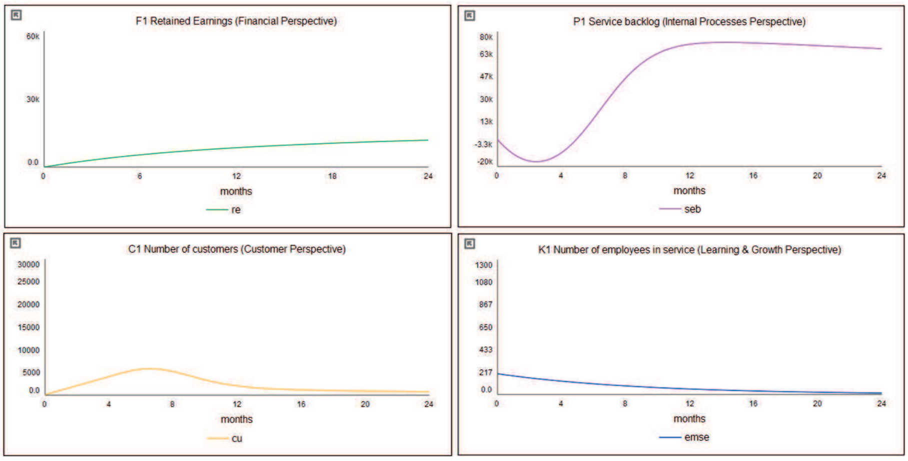

Figure 13. The critical results – increase in *Cosm*

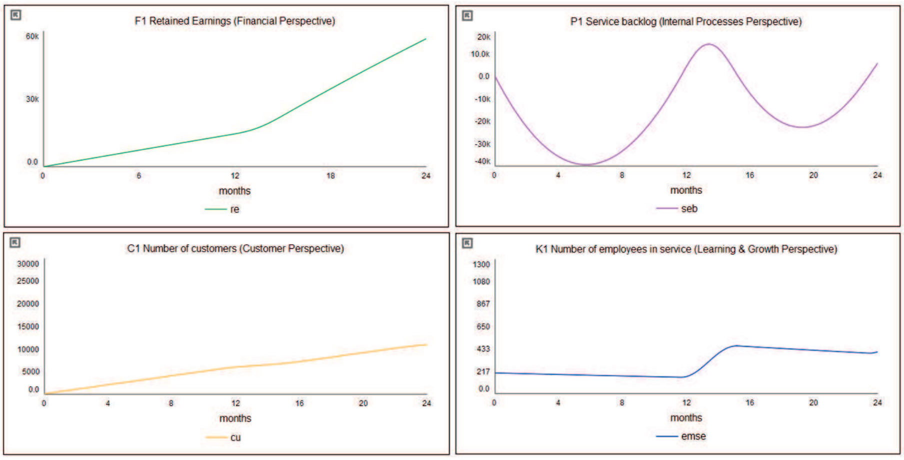

Figure 14. The critical results – increase in *Emseir*

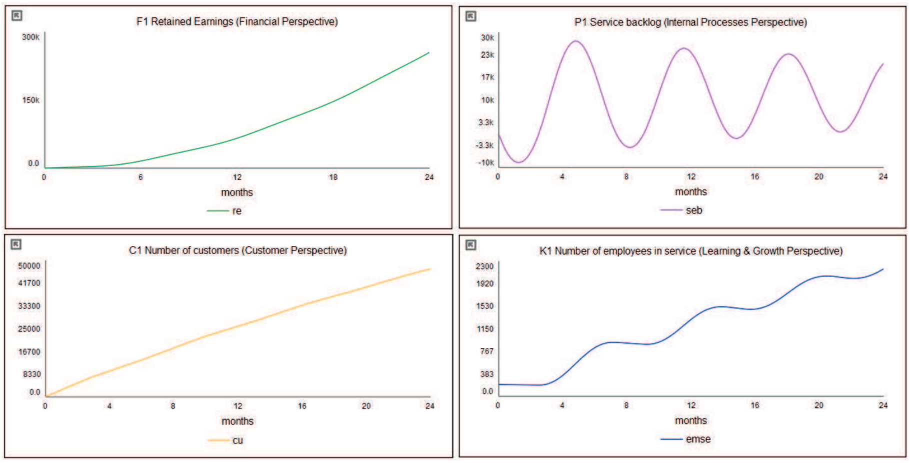

Figure 15. The critical results – increase of *Emseir* & *Cuir*

but also to effectively respond to other challenges of competitiveness, such as: efficiency of marketing activities, care for customer relations/customer service, company image, including, as well, the actions at the level of internal processes of the company – and yet some more (not directly addressed in this paper, though), like understanding/support of employees, motivation, etc.

Very much the same types of competitive advantages, which are achieved in a dynamic environment, can vary to a great extent, depending upon the specific value chain, and upon the conditions of internal and external environment of the enterprise. Thus, the actual dynamic content of the competitive advantage becomes dependent on variables in such a way that small changes in the initial conditions/values may cause significant development movements or slowdowns. In the dynamic approach, enterprise shall be therefore seen as a dynamic open system, whose competitive advantage (but also stability) is essentially dependent upon the permanent changes/adaptation to the surrounding conditions – and this shall be the subject of constant supervision, monitoring, and, possibly, control (meaning the impact on or direct steering of the object-describing variables), and here, the approach adopted, with the use of System Dynamics and BSC seems to be greatly helpful, what has been shown, e.g., for the simulations of critical values, that if neither tracked nor controlled in advance may cause unstable / unpredictable behavior of company in its key areas.

The novelty of this work is application of combined Balanced Scorecard and System Dynamics methodology in enterprises from the highly turbulent telecommunication sector, characterized nowadays by macro-economic uncertainty and sustained market downturn vs. shareholder expectations. This research may serve as initial foundation framework for the sector (where most of performance management programs still rely on lagging* indicators (monitored after a specific economic activity occurs) for the set-up and use of "simple leading† indicators", specific to telecommunication industry, type of customer increase rate vs. service backlog vs. employment rate, etc., and its dynamic correlations in two-fold approach:

1. for predictive image across fundamental processes at the enterprise level of e.g. customer, product or service, delivery, management and support perspectives,
2. for multi-faceted monitoring and benchmarking with elaboration of possible controls to achieve the desired business performance expected by the shareholders,

to enhance and transfer the business performance of an enterprise into dynamically oriented and measured metrics to closer follow the enterprise's essential properties, such as complexity, dynamics, and nonlinearity operationally. This approach becomes even more important in today's shift towards the digital economy, with the rise of digital platforms, Big Data, what may become intrinsically the new source of competitive advantage for enterprises by the use of combinations of new technologies and targeted business methodologies. The simple leading indicators derived from the SD & BSC modeling may greatly complement the sources of information from internal business processes or macroeconomic leading indicators that apply to the general economy, or even microeconomic leading indicators, specific to an industry and enterprise that are obtained from external events, and thus further reduce the cost and increase the reliability of leading indicators as such. Companies that use leading indicators, according to respective studies (see, for instance, Gartner Inc. G00171674, 2009), earn almost 3% of higher return on assets and more than 5% of higher return on equity, thus, owing to the obtained predictability, they may outperform their competitors and further extend the effect of competitive advantage.

Further work on the subject here presented shall consist in the following undertakings:

System Dynamics modeling shall be yet anchored to the "soft" operational research models, and comprise factors from the areas of intuition, experience, and systems thinking (based on author's extended professional experience and long corporate track record), hence it ought to enhance the elaboration of strategy and the competitive advantage building.

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*Lagging indicators measure the end-state (typically financially oriented and "backward-looking") objectives or desired outcomes; they include all accounting metrics, which are often constructed on the basis of the income statements, balance sheet and cash-flow statements. Although lagging indicators are important for managing business performance, they provide little insight into how to exploit opportunities and mitigate risk (as they do not predict them).

†Leading indicators measure activities or events that precede the desired business or financial outcomes, and have a causal relationship with specific metrics and financial outcomes. Leading indicators look at more real-time events that contribute to lagging indicators.

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Appendix

Initial values of variables and parameters values for the basic simulation model:
$cu = 100$; $emse = 200$; $kl = 5000$; $re = 0$; $seb = 0.0001$;
$Cosm = 50$; $Cot = 15$; $Cuir = 10$; $Emsedr = 0.02$; $Emseir = 0$; $Klne = 40$; $Klqea = 1$; $Ov = 1.1$;
$Pr = 0.17$; $Sa = 1.8$; $Txr = 0.2$.