# MODELING OF ESSENTIAL CHARACTERISTICS OF DYNAMICS OF THE ECONOMIC ENTITY

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**Abstract**

*Economic entities may exhibit dynamic characteristics, both linear and nonlinear. In order to model the dynamic behavior has been presented the approach with use of transfer function. This function is understood as the relationship of the Laplace transform of the output signal to transform of the input signal. The purpose of this cognitive procedure is to replace the time domain with frequency domain. The transfer function is described in this case as follows: K (s) = Y (s) / X (s), where Y (s) is the output signal and X (s) input signal for dynamic linear part. For the nonlinear part of the economic entity has been applied deterministic modeling approach with use of the Lorenz attractor. The consequence of this modeling of linear and nonlinear dynamics was to develop a theoretical model to control selected behaviors of economic entity to enhance decision making quality / company's management / strategy*

**Key words:** *economic entity/system, non-linear dynamics, control, transfer function, attractor, management*

## 1. INTRODUCTION

"What now is has already been; what is to be, already is" (The Book of Ecclesiastes (3, 15))

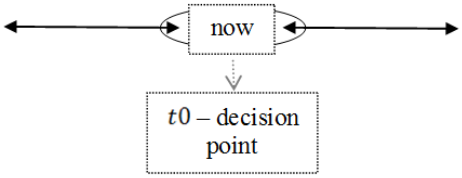



*Fig. 1 – Events perspective and possible decision trigger*

Above mentioned citation is inspiring in its nature, indicating a correlation between present, past and future, what intuitively tends to give some quick, simplistic and holistic response of determinism, but perhaps in some range only, as human beings may always trigger a decision point (fig.1) for shaping of the future, what seems to be not predetermined, due to human free will, what in terms of economic entities may translate further to enterprise control, strategy build / management, but charged by past episodes?

Surely, for such topic to confront with, it shall be taken a wider view, or contrary - be nailed down into criterion: i.e. effectiveness of the company, and if explored well, it has to be seen as the result of effective management derived from strategy, which ultimately leads into achievement of the assumed targets. In any case, the trigger is the decision point, what usually is own experience, know-how, use of the available information and its meaning for decision making, and if applicable, use of analytical methods, which may support/indicate directions for the future actions.

Economic entity, the company as such, is a set of different structures (personal, physical, financial, informational, etc.) and processes (main of: customer, product, delivery, management and support) interrelated with each other, what does create a kind of economic phenomena of cumulative effect of multiple events occurring in different sub-areas of the company (structures, processes), distant from each other over time and space. Due to complexity and coherence of such system, the effective methods of its analysis and evaluation in a holistic manner shall take into account possibly enterprise's

static and dynamic behaviors, what in terms of strategy building (positioning, design and execution – see 2.1 below) may engage different methods and models, creating potentially some space for development of either a new methods or at least an approach of analysis the economic system (or combination of existing ones), and commensurately to the outcome - practical applicability.

Over the years many of researchers, practitioners / executives placed their efforts to describe, design and implement various strategic models of an enterprise (economic entity). Were they useful to provide comprehensiveness in decision making with its goal, to win/survive? – the question itself is probably rhetorical, as the answer usually comes in bridging abstraction and practice.

Having still, a more holistic view, regardless model used or not in strategic management, some set of strategic goals apply (selective listed below):

- bundles of values (production, economic, social) implemented by the organization, and relating to its existence and development in the context of relationships with the environment,
- desirable state of affairs of the organization to achieve the path organization is moving in the longer and shorter periods,
- sets of specific effects of actions,

setting-up a desirable sub-set of initial guidance at once, yet to be composed further with analysis of environment / analysis of resources, vision, mission and goals of the organization with its strategic options (/and its selections) as well as implementation (/and adjustments of the organization' structure and architecture) towards realizable path of desired strategy creation.

For the sake of this paper let's apply a lean categorization based on two-dimensional approach of the criterion of static and dynamic systems modeling, which will be followed next.

## 2. METHODOLOGY

### *2.1 Static systems*

The main contemporary management tools and practices (van Assen, van den Berg, Pietersma 2009) can be applied in business management. They are very well categorized (table 1) and used in practice with its aim to:

- analyze and plan a company's strategic position and provide answers to strategic questions (strategic models, i.e. Porter's 5 forces or BCG matrix) – strategy positioning,
- organize a company's processes, resources and people (tactical models, i.e. Business process redesign) – strategy design,
- change organizations and implement best practices (operational models, i.e. The balanced scorecard) – strategy execution.

*Table1 – Main contemporary management tools and practices*

| | |
|---|---|
| A | Activity-based costing |
| | Ansoff's product / market grid |
| B | Balanced scorecard |
| | BCG matrix |
| | Beer and Nohria - E and O theories |
| | Belbin's team roles |
| | Benchmarking |
| | Blue Ocean Strategy |
| | Branding pentagram |

| | |
|---|---|
| | Business process redesign |
| C | Change quadrants |
| | Competing values |
| | Competitive analysis: Porter's five forces |
| | Core competencies |
| | Core quadrants |
| | Covey's seven habits of highly effective people |
| | Curry's pyramid |
| D,E,F | DCF |
| | DuPont analysis |
| | The EFQM excellence model |
| | Factory gate pricing |
| G,H,I | Greiner's growth model |
| | Henderson and Venkatraman - strategic alignment model |
| | Hofstede's cultural dimensions |
| | House of purchasing and supply |
| | Innovation circle |
| K,L | Kay's distinctive capabilities |
| | Kotler's 4P's of marketing |
| | Kotter's eight phases of change |
| | Kraljic's purchasing model |
| | Lean thinking / just-in-time |
| M | MABA analysis |
| | Market-driven organisation |
| | Milkovich's compensation model |
| | Mintzberg's configurations |
| | Mintzberg's management roles |
| | Monczka's purchasing model |
| O | Off shoring / outsourcing |
| | Overhead value analysis |
| | Quick response manufacturing |
| R | Risk reward analysis |
| | Roadmapping |

| | |
|---|---|
| S | Scenario planning |
| | Senge - The fifth discipline |
| | Six thinking hats of de Bono |
| | Strategic dialogue |
| | Strategic human capital planning |
| | Strategic human resource management model |
| | SWOT analysis |
| | 7-S framework |
| T,V | The value chain |
| | Value-based management |
| | Value disciplines of Treacy and Wiersema |

*Source: van Assen, van den Berg, Pietersma (2009) - (reworked)*

These models can be then further mapped against functional areas and levels of management decision making:

- strategy and organization - models used for formulating strategy and designing organizational structures,
- finance and governance - models used to design governance mechanisms and related performance metrics, including financial instruments,
- marketing and sales - models used to formulate marketing and sales policies, to structure marketing and sales departments, and to develop operational marketing and sales instruments,
- operations, supply chain management and procurement - models used to formulate operations, supply chain and procurement policies, and methods to design, optimize and implement best practices for operations, supply chains and procurement,
- innovation and technology management - models related to innovation management. Models used to formulate R&D and technology policies, to align R&D technology objectives with corporate strategy, to develop R&D instruments,
- HRM, leadership and change - models used to formulate HR policies, and to design and implement HRM practices and instruments. Models and methods related to change management are also included in this category

, with above, the conclusion at this point is:

- management models have been designed to resolve common problems and challenges in business. At best they provide a new way of seeing a situation that will result in change. The models may be applied strategically, tactically or operationally. Some of them are typical problem-solving tools, designed to improve efficiency and effectiveness. Most of them are designed to solve specific problems in a specific situation. Management models and theories can therefore help to gain clarity in business by reducing complexities and uncertainties. Yet, no management model / or group of models, can guarantee to deal with an organizational problem objectively, and to the best of their ability, because their predictive value is limited, caused by their native nature (to describe and predict behavior of companies and industries): modeling for the time “t” returns outcome related to the same time “t”; modeling for the time t+1 returns outcome related to t+1, etc., engaging by the same some statics, whilst in dynamics approach, modeling of the value (input) in the current moment “t” has also impact on value of the output in future moments “t+n”, what in fact reminds so called memory effect where value of the output depends on value of the input in the past.

*2.2 Dynamic systems*

Porter (1998) emphasizes that evolution of industries is dynamic and path dependent: corporate (and country-level) capabilities acquired during previous competitive episodes shape the context for future competitive events. Moreover, the accumulation of competitive advantage can be self-reinforcing, suggesting at least one way in which industries are nonlinear.

To follow above, by engaging dynamic approach into analysis, an enterprise can be considered (symbolically) as economic system (entity) characterized by events with its own dynamic each. Over time and space in such system happen multiply changes and evolutions (driven in general by people and internal and external processes/forces) what leads to an observation of many complex phenomena (derived from, and characterized by such dynamic changes), being immersed as well into trends/patterns and discontinuous changes. Its recognition may be important for the analysis and prediction of the development trends of studied phenomena and can complement predictive or decision-making models (Zieliński 2000), and yet business cycles of the economy or cycles on capital markets that shall be taken into account too. Business cycle in its meaning shall be understood as type of fluctuation in the global business in regards to production and employment fluctuations around the long-term trends (Begg, Fisher, Dornbush 1995). The cycle consists of a rule of the following phases: expansion; the economic boom that appears at about the same time in many economic endeavors; following after him in the same form of recession / shrinking business ventures; then boom, which goes into the expansion phase of the next cycle.

It is not all, there are as well other cross-functional relations, where not only industry structure influences a company behavior, but company behavior in turn can alter the structure of an industry and the frame of competition.

It has been imminent that at certain point of strategy positioning, design and execution, there will be a question how an economic entity will behave in the context of various changes caused by interactions among enterprises, government, labor, consumers, financial institution, markets, etc. of the company environment (internal and external of company view).

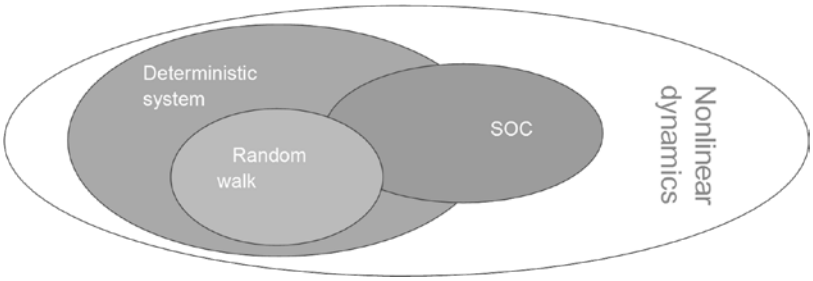
In the attempt to capture these complex phenomena derived by the dynamic and cross-functional changes within the company and its environment, it all tends to an alignment of such object (an enterprise) into a nonlinear dynamic system due the essential unpredictability with the emergence of distinctive patterns (Levy 1994), therefore the use chaos theory and fractal analyses may apply, given that conventional heuristic decisions' structures or equations were often unsolvable due to its complexity being depended on too many of components (Kudrewicz 1993). To come closer into the clue of the topic in sense of theory of dynamic nonlinear systems and its possible implications into strategy for behavior' predictability of companies and industries, it is assumed to use Lorentz' model of evolution of atmospheres as progenitor for further studies in different fields sciences with use of so called strange attractors, appealing from the point of chaos theory.

The development of chaos theory (Tempczyk 2013) as an independent discipline research began when scientists from different fields of natural sciences and engineering have learnt to solve (using computers) nonlinear differential equations, so have been discovered specific properties of its solutions. This process started in the early sixties of the twentieth century, and has not yet ended. It is not known therefore, what will be the full image being developed theory of nonlinear phenomena, because there are still new methods, results and problems. Fortunately, it doesn't need to be waited until its inception, because of what was achieved so far in science emerges a new, more integrated model of the dynamics and properties of complex systems, which covers almost all areas of the phenomena studied by empirical science. In such model, there are several interrelated concepts such as nonlinearity, attractor, bifurcation, etc.

To organize, systematize and simplify above let's use definition of chaos given by the Royal Society, London 1986: "Chaos = Stochastic Behavior in a Deterministic System", what sets-up the approach itself. Chaos therefore can be seen as part of overall complexity theory where for complex dynamical systems occur aperiodicity, limitation, causality, sensitivity to change. Complexity theory maintains that self-organization enables systems to evolve to higher level of development. The common base for

both chaos and complexity theory is that both are part of nonlinear dynamics. Nonlinear dynamics and its modeling constituents may exhibit as well a complementary structure of deterministic system (fig. 2) including so called random walk with it's on the edge to chaos component of SOC (self-organizing-criticality) Szydłowski et al. (2011)

*Fig. 2 – Constituents of nonlinear dynamics*




*Source: own research*

Moreover, since the nonlinearity can be defined as the opposite of linearity, it needs to be also understood what it means lack thereof - in the sense of dynamics, and contrary, if linearity can complement the modeling of economic entity.

What comes as the most imminent after all for modeling of essential characteristics of dynamics of economic entities is in fact: the control. In its attempt to apply, both the transfer function of economic entity, representing a more "linearized" part within enterprise as well as chaotic behavior modeling, representing more nonlinear native features of economic entity will be used.

### *2.2.1 Transfer function modeling*

Economic entity can symbolically be described on the basis of generalized state equation with its input (x) and output (y):

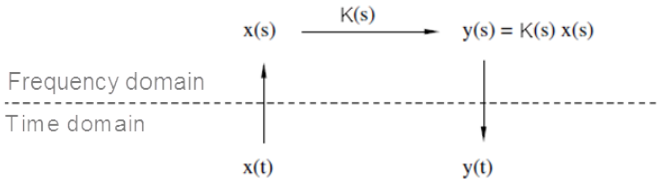
$$F(x,\frac{dx}{dt},...,\frac{d^n x}{dt^n}\,y,\frac{dy}{dt},...,\frac{d^n y}{dt^n})$$

To overcome stipulations of this generality, symbolic formal description of transfer function is K (s) = Y (s) / X (s) (Wang et al. 2008) is introduced for modeling of dynamic linear part of economic entity (on the basis of assumption made above in sense of "linearized" part. Y (s) is the output signal and X (s) input signal:

$$\mathrm{K(s)} = \frac{\mathrm{Y(s)}}{\mathrm{X(s)}}$$

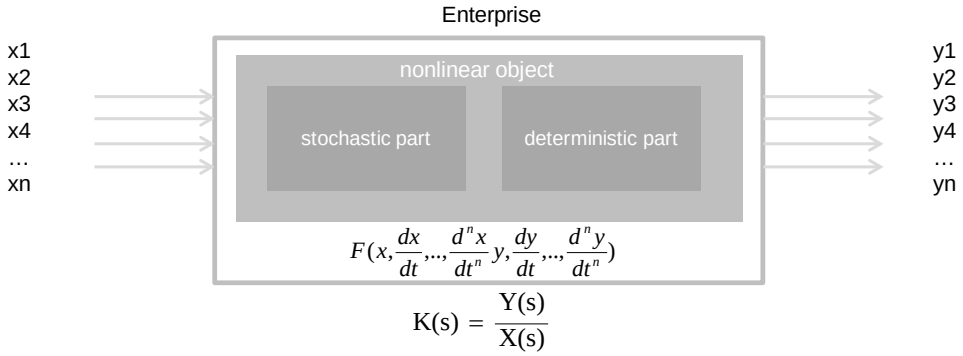
The purpose of such approach for "linearized" part is to replace the time domain with frequency domain (fig. 3), what's the basis of Laplace transformation used within (usefulness of Laplace transformation is utilized in the analysis of linear dynamic systems and by that solving of its differential equations).

*Fig. 3 – Cognitive procedure to replace the time domain with frequency domain*




Ratio of the Laplace transformation of the output signal Y (s) to the Laplace transformation of the input signal X (s), under the zero initial conditions, is called the transfer function K(s) of the system, binding input x1…xn information with y1…yn (for each xn/yn shall be calculated separate transform function setting-up a matrix of transfer function for economic entity (fig. 4).

*Fig. 4 – Enterprise modeling as a control system*




*Source: own research*

Transfer of information in control systems is possible either continuously or discretely. For continuous control systems, signals are continuous functions described in time and these functions can take all values within the range of variability. For discrete control systems there is at least one active element in a discrete manner i.e. that signals at the output of the element can take only some selected values or signals occur at specific points in time. Other point of view or perception does say that discrete systems differ from continuous ones that the control of the output may happen at certain, usually periodic interval. In other words there is kind of sampling of information, leading into receiving of discrete signal. In order to describe such objects shall be used discrete function. Mathematical description uses so called transformation Z (transfer function) as a discrete version of transformation Laplace' a for continuous objects. The Laplace transformation is a widely used integral transform in mathematics. It is a linear operator of a function f(t) with a real time argument t ($t \geq 0$) that transforms f(t) to a function F(s) with complex argument s, given by the integral:

$$F(s) = \int_0^\infty f(t)e^{-st}\,dt.$$

Knowledge of transfer function (transmittance) helps to learn the general properties of the system, independent of the input. Transfer function is also used to simplify the calculation of a system composed of many elements, units.

The transmittance characteristic feature is its independence from the input signal - transfer function describes a system, and if no changes were made in it, the transmittance is always valid, hence a certain course of action can often be used for objects modeling. In order to derive transmittance, and the right method for its identification, there are two possible scenarios. In the first, transition function

of the object is obtained on basis of the physical phenomena by correlation of input and output values. In the second scenario, the transmittance is quantitative approximation of dynamic characteristics of the system (object), expressed through the so-called. step response (due to the complexity of the same transmission). For system testing at the input of the unknown system' properties shall be applied a known signal (usually stroke unit) and further shall be observed the system response. The output signal approximates a mathematical function, and transmittance of the system is being determined. Knowing the transfer function of an object it can be found what kind of the signal is at the output for any given input. Another common application is to determine the value reaching the output signal with given input. The transfer function can be applied to linear objects, which means obvious limitation its usefulness for nonlinear, where output characteristic depends on the amplitude of the input signal (nonlinear systems).

### *2.2.2 Chaotic behavior modeling*

Chaotic behavior modeling, representing more nonlinear native features of economic entity comes along with analogies to modeling of the dynamics of turbulent flow in fluids by use of non-linear differential Stokes equations, followed later by Lorenz (1963) for weather research to develop three-dimensional model of gas molecules (atmospheres) evolutions, depending on the temperature (x), wind speed (y) and humidity (z).

$$\frac{dx}{dt} = a(y - x)$$
$$\frac{dy}{dt} = x(b - z) - y$$
$$\frac{dz}{dt} = xy - cz$$

By following just two "almost" identical evolutions not stating form very similar condition, at first their trajectories were indistinguishable. With time, they split-up significantly, so they became completely different. Further, for many more atmospheres, which didn't start form the very similar initial conditions either, after a period of time, they cumulated to the same pattern – "strange" attractor.

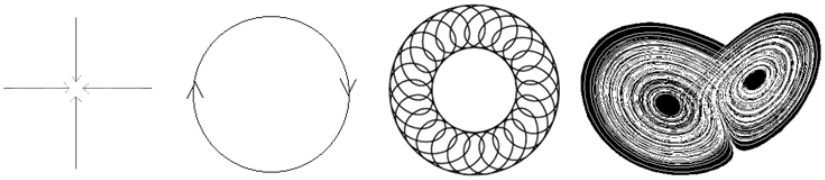
Coming closer to the economic entities, Zhao et al. (2011), developed model of the integer-order financial system described as well by three differential equations with variables (x) on interest rate, (y) on investment demand and (z) on price index

$$dx / dt = z + (y - \mu)x$$
$$dyldt = 1 - \beta y - x^2$$
$$dz / dt = -x - \nu z$$

, what surprisingly behaved similar way in the phase space as "strange" attractor exemplification.

The term system's attractor is characterized as the way in which a system operates (Williams, 1997). Several of other studies (Pryor, Bright 2013) confirm as well that economic entity being considered as organizations and people, may behave in characteristic manner as the system operates seen as: point, pendulum, torus and strange type of attractors (fig. 5), concluding in turn that the healthy organizations may exhibit more similarities to the "strange" attractor type.

*Fig. 5 – Selected attractor types*



*Source: Oestreicher, 2007*

Point attractor represents a system that seeks to function to achieve and state or goal. Organizations functioning as point attractor will stress deadlines, objectives, sales targets, incentives and production output levels. Setting and achieving goals became the major if not the sole criteria by which organizational success is evaluated.

Pendulum (cycle) attractor represents a system with diametrically opposed solutions in operations – either / or terms

Torus attractor represents a system that encourages "silo" thinking and funding with mentality on providing a service/product and seeing after if anyone wants either. In such organizations is being placed too much confidence in established procedures and systems

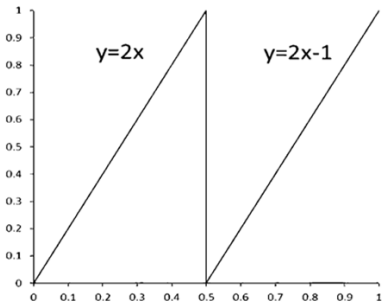
Strange attractor represents a system seen particularly as dynamic open system, whose stability comes from continual change.

Whilst point, pendulum and torus attractors characterize expectations about fundamental stability and predictability of system and the belief that systems can be foreseen and controlled, what as practice shows is naive (Pryor, Bright 2013), the strange attractor limits a system to move through an infinite number of points without repetition, but with self-similarity and susceptible to sudden alternation in trajectories and shapes of the system constituting to the healthy organizations.

Mathematically in chaotic systems it's difficult to calculate state of the system at a specific time, therefore researchers usually model systems as discrete difference equations, which specify what the state of the system will be at time "t+1", given the state of the system at time "t". Computational simulations can be then used in consequence to see how the system evolves over time.

Guckenheimer (1970), proposed the simple model trying to understand internal dynamics in the Lorenz attractor. The model showed just two basic dependencies of: $y=2x$ (if $x<0.5$) and $y=2x-1$ (if $x>0.5$)

*Fig. 6 – Internal strange attractor dynamics - simplified*




The algorithm of internal dynamics of trajectories in the attractor follows the following pattern (example):

If x is equal to i.e. 0.2 – starting point trajectory, then y = 0.4; a new starting point x becomes 0.4, then y = 0.8; If a new starting point x is equal to 0.8 now, then y = 0.6; the new starting point x in this case is 0.6, then y = 0.2, etc...

Shoji (2013) proposed nonparametric estimation of nonlinear dynamics by local linear approximation. By specifying a metric such as the standard metric or the square metric on the Euclidean space and a weighting function based on such as the exponential function or the cut-off function, it is possible to estimate values of an unknown vector field from experimental data for modeling of time series with high frequencies by application of continuous time stochastic process formulated by stochastic differential equations with use of standard Brownian motion as a random process.

Based on these, similar approach will be taken to model example of time series for in the chapter 4.

## 3. CONCEPTION

Economic entity being a complex ecosystem with structures, processes, with various internal and external interactions requires a solid methodology framework. An approach trying to close the gap has been presented in chapter 2 to underline the key points of modeling assumed. In its aim, is to develop theoretical and practical model to control selected behaviors of economic entity to enhance company's management and decision making quality, so the conception framework construct is build on the following elements:

*3.1 Use of standard models and tools in order to build strategies*

*3.2 Modeling in the context of nonlinear dynamics*

a. economic entity (enterprise) as a dynamic, nonlinear economic object described for control of its parameters in the perspectives of financial, customer, internal processes and growth – the balanced scorecard approach (Kaplan & Norton, 1997)

b. assumption of randomness and determinism as native characteristic features of economic entity operations (chance and necessity coexist)

- use of so-called strange attractor model class in the areas of balanced scorecard
- estimation of prediction quality of derived control parameters
- estimation of transfer functions K(s)

*3.3 Simplification of the structure*

*3.4 Control of economic entity dynamics to influence object operations/ support management process*

a. shifting the trajectory of the controlled parameter (on the basis of balanced scorecard data) towards entry on a different orbit in a phase space, resulting the influence on the selected process / operations of enterprise, i.e. reaching faster desired state (control of internal object dynamics)

b. stabilization of the chaotic object / its orbits. by use of the feedback with a time delay control method (Pyragas 2014) in selected area from balanced scorecard (chaos stabilization)

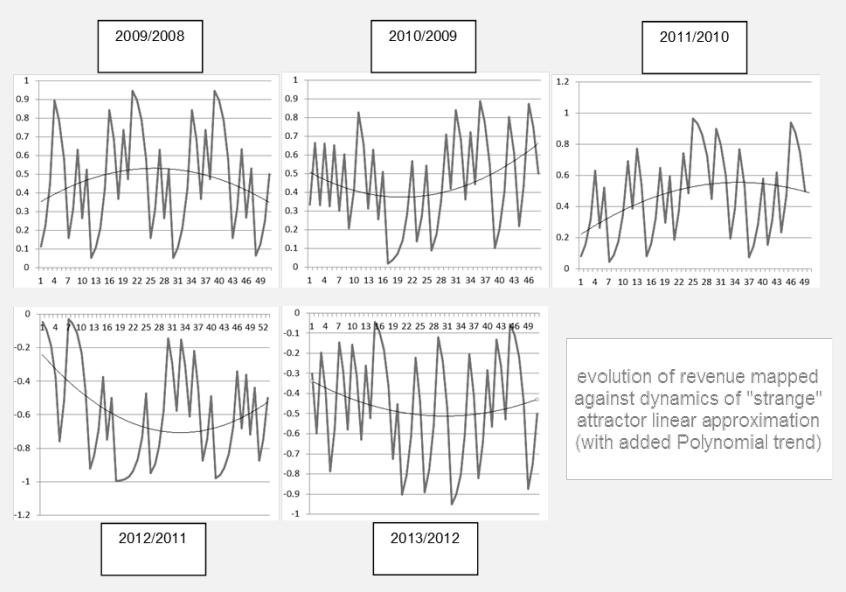
## 4. COMPUTATIONAL APPROACH

Computational approach for the sake of this paper is limited to selective issue, where one dimension of financial perspective of balance scorecard being as exemplary, aims to concatenate logically the research problem being undertaken in this course - following principles of 2.2.2 - in the sense of financial time series modeling with its predictability, what shall serve in consequence to derive controllability of economic entity (being representative for nonlinear part – pic.5).

Data: a time series (incomes of an enterprise) is normalized using the internal dynamics dependencies of the Lorenz attractor as a "linear approximation", creating strings of data. After the "n" iterations run

~ 52 (same for each period – fig. 7) is achieved state of equilibrium. If going forward with computations beyond equilibrium - the output parameters diverge exponentially, which eliminates the usefulness of the calculations to determine the prediction horizon (beyond equilibrium).

*Fig. 7 – Evolutions of enterprise incomes against internal dynamic of strange attractor*



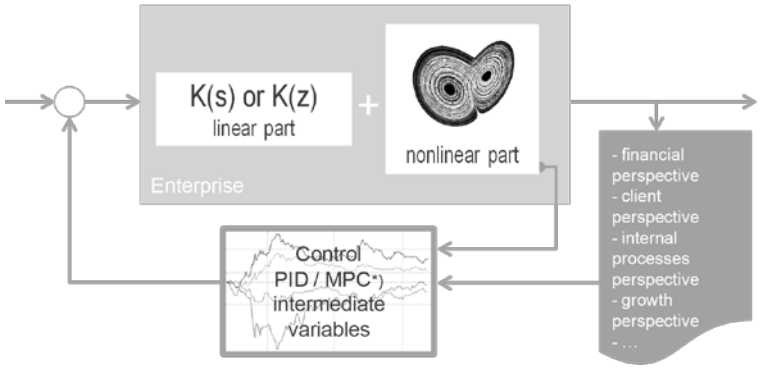

*Source: own research*

In next proceedings (Zieliński 2000, Peters 1997, Kapecka 2013) has also been computed a predictive horizon of ~ 2 weeks, with its aim of reuse obtained data for predictive control of economic entity.

Inclusion of control for economic entity:

Economic entity - the Enterprise - does not seem to be completely a chaotic (adversarial to the suggestions raised by Pryor, 2013), therefore or as a result of human actions seeking to organize the material things, these also may be seen as linear dynamic part (consciously and deliberately controlled operating ventures) in the form of the object transfer function K(s) for continuous modeling or K(z) for discrete resulting in set-up of a holistic approach for economic entity control, including linear and nonlinear modeling (pic.5)

*Fig. 8 – Control of economic entity*




*Source: own research*

*) Control type: PID (Wang et al. 2008): Proportional - Integral – Derivative) and / or MPC: predictive control derived from internal dynamics of nonlinear chaotic modeling (cyclical solving optimal control tasks, where the first part of the found solution (control function) is fed to the input object)

Control of the economic entity is a complex topic and does not need to happen in a direct way, for example - to improve the quality of the product does not necessarily has to be checked each product several times – the right means of "control" can be i.e. improvement of labor relations and by that finding ways to reduce the level of defects.

Control of economic values (table 2), such example net sales, turnover, sales of services, the efficiency of R & D Action Plan leadership, competitiveness of products and services, CPV (customer Perceived value), the number of confirmed interruptions, delivery on time, or the creation of intellectual value , etc. requires an impact on related variables (as mentioned above), for example: in order to achieve higher incomes from the sales it might be necessary to invest in R & D or increase / reorient advertising markets, target customers, what creates many opportunities for action being perhaps not always optimal. By controlling the balanced scorecard (table 2), which allows monitoring of economic entity performance by measurement of past successes (achievements) and setting goals for the future, it should be found an optimal relationship between areas, and thereby determined what parameters shall be controlled to achieve required output value of a variable.

*Table2 – Balance scorecard – reworked example*

| | Scorecard - 2014 | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | P11 | P12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Financial | Net sales | | | ● | | | ● | | | ● | | | ● |
| | EBITDA | | | ● | | | ● | | | ● | | | ● |
| | Free cash flow | | | ● | | | ● | | | ● | | | ● |
| Markets | Sales performance - | | | ● | | | ● | | | ● | | | ● |
| | Sales performance - | | | ● | | | ● | | | ● | | | ● |
| | Sales performance - | | | ● | | | ● | | | ● | | | ● |
| leadership | R&D efficiency | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | Roadmap leadership | ● | | | ● | | | ● | | | ● | | |
| | Design-for-serviceability | | | | ● | | | ● | | | ● | | |
| | Portfolio competitiveness | | | ● | | | ● | | | ● | | | ● |
| Services | Services revenue | | | ● | | | ● | | | ● | | | ● |
| | Services pipeline | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | Attach rate | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Quality | Customer perceived value | | | ● | | | ● | | | ● | | | ● |
| | Number of confirmed outages | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | Virtual zero software programs | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| Execution | On-time delivery | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | Company direction and culture | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | Fatal and critical incidents | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | Lean execution | | | | | | ● | ● | ● | ● | ● | ● | ● |
| Innovation | Portfolio innovation | | | ● | | | ● | | | ● | | | ● |
| | Customer perception | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |
| | Creation of intellectual property | | ● | | ● | | ● | | ● | | ● | | ● |

*Source: an enterprise in IT business*

## 5. CONCLUSION AND FUTURE WORK

Chaotic behavior modeling (2.2.2) seems to be have limited applicability for modeling of enterprise business due to rather short term forecasting values, thus simulation models are seen to be more applicable to a kind of business with frequent changes/transactions occurring (i.e. logistics), where if accurately specified starting conditions can yield forecasts for some time periods, implying further possibility of control - contrary to a more stable kind of IT businesses being analyzed, characterized by inertia, remarkable time delays on given input, etc., where short term forecasting does not play an

important role. Theory of control may have its place in the modeling of chaotic nonlinear systems either by its linearization and use of standard transmittance methodologies for continuous and discrete objects or by proceeding for nonlinear, whilst future works shall confirm its practicality.

Existing approaches of control (or stabilize) chaotic behavior by use of feedback with a time delay shall be carefully tested against all variables from balanced scorecard through the proper verification of chaotic time series by reconstruction of phase space, decomposition empirical / inner function (EMD) / (IMS) or at least by Hurst exponent (if applicable) used as a statistical tool for the classification of time series for random and non-random arrays due to the suspicion that some of variables may exhibit homoscedasticity, caused by intrinsic property of its processes at economic entities.

Further aspect of the research is applicability of SOC ("on the edge of chaos") as self-organized systems are weakly chaotic, what might be favorable from methodology point of view towards a longer forecasts / prediction periods estimations.

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