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DYNAMICS OF PRODUCTIVE SYSTEM DEVELOPMENT*

Introduction

Dynamics of productive systems development at the time of their management in the era of turbulence is a very actual issue. Let us try to look at the dynamics of productive system development issue from historical point of view. Approximately forty years ago Prof. F. Valenta entered into the awareness of academic community by introduction of his concept of innovation theory. This longitudinal study included analysis of many theoretical sources and interpretation of statistical data from entrepreneurial practice. In his last publications he generalised up-to-date world knowledge with regard to his previous scholar work[1]. His outstanding contribution lies foremost in the application of business cycles and innovation theory within entrepreneurial practice and entrepreneurship theory. This course of theoretical thoughts arises from presumption of particular natural 'cyclic' order of a productive system, i.e. enterprise. Schumpeterian Business Cycles graphs (1939), Junglar investment, i.e. crisis cycle waves (1860), Kitchin wave (1920s'), Kondratiev K-waves (1926) or Wardwell wave (1927) are common to academic community. Lengths of economic waves vary from three year (Kitchin), through ten year (Schumpeter), to twenty-five year (Wardwell) or even fifty year (Kondratiev) waves. Three-month innovation cycles can be currently observed in semiconductor industry[2].

American author Dator[3] gives us another look on the economic cycle's issue. In the world of intensive and continuous innovation and decreasing continuity, he expects arrival of new waves and cycles. Therefore it is necessary to find causes and origins of new waves based upon political or economical factors. He mentions the creation of relation between consumers and debts (credit cards, etc.). He also reminds that new technologies must go hand in hand with social changes. The future can be perceived as of three components:

- continuation of things found in the present, and also found in the past;
- things that existed in the past, but not in the present, that will appeal again in the future, and things that did not exist in the past but are very much a part of

* This article is based on several topics, that have arisen from discussions of prof. Z. Mikolas and doc. O. Lysek, docent emeritus, co-founder of Industrial Economics and Management module (currently Business Administration) at VSB-Technical University of Ostrava in 1970 and also in cooperation with Innovation theory protagonist prof. F. Valenta. The paper also develops some thought from the monograph Competitive Potential of Industrial Enterprise by Z. Mikolas and Co., Praha: C. H. Beck, 2011).

1 F. Valenta: *Inovace v manažerské praxi.* 1st ed. Velryba, Praha 2001.

2 Z. Mikoláš: *Jak zvýšit konkurenceschopnost podniku.* Grada, Praha 2005.

3 J. Dator: *Alternative Futures for K-Waves*. Ed. T.C. Devezas. *Kondratieff Waves, Warfare and World Security*. IOS Press, Amsterdam 2006.

the present but that will not exist (or be as important) in the future, these things often appear as cycles or 'spirals';

- things that do not exist now and never existed before, but will in the future, i.e. novelties are the third component.

In the economical (entrepreneurial) domain innovation is mostly identified with the subject that makes a change in the production structure[4]. Innovation in this approach is perceived as a new product, tool, material, etc. Prof. Valenta perceived innovations as the developmental movement in real structures induced by incoming novelties (products, raw materials, supplies, machines, etc.). This creates a need for new technology, labour skills, organization and governance, management, etc. In this approach we perceive any kind of structural change as an innovation.

In his article author Filson[5] was dealing with observation of changes in the information technology industry (personal computers) in period 1974-2000. The index of PCs price had decreased more then by a half and the trend follows a linear development. The number of firms in the industry have strongly risen and then decreased and again slightly rises similarly to a bullwhip or Fibonacci sequence. The quality and quantity of production have risen exponentially.

Also the work of De Groot and Franses[6] supports claims above. They suggest that basic innovations are one of the important growth factors. Their study deals with following the growth and innovations in the period of 1764-1976 with regard to general economic cycles. Observation of waves has long tradition. It seems that all of them are following the same average pattern. Cycles that were found are corresponding with periods of 5, 13, 24, 34 and 61 years, that is also corresponding with economic cycles. There is a striking resemblance to Fibonacci sequence. Their assumptions are declared in another article[7].

The basic common characteristic of innovations can be generalised as it is running with time. We can study it:

a) as time relation of an innovation, when examining the course of a structural change in the course of its life cycle, i.e. history of each innovation;

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[4] O. Lýsek: *Příspěvek k teorii řízení inovačních procesů.* In: Sborník. EkF VŠB, Ostrava 1988; Idem: *Příspěvek k teorii inovací a možnosti jejího využití při řízení inovačních procesů.* In: Sborník prací OPF v Karviné, díl 2. OPF SU, Karviná 1994.

[5] D. Filson: *Product and Process Innovations in the Life Cycle of an Industry*. "Journal of Economic Behavior & Organization" 2002, Vol. 49.

[6] B. De Groot, P.H. Franses: *Stability through Cycles*. "Technological Forecasting & Social Change" 2008, Vol. 75.

[7] B. De Groot, H.P. Franses: *Cycles in Basic Innovations*. "Technological Forecasting & Social Change" 2009, Vol. 76.

b) as time relation of innovations, when examining the sequence of single innovations, as they follow the sequence in time.

The examination of both time relation of innovations and mutual connection of knowledge can be used when formulating specific patterns (order) of the structural change development.

Presented 'cyclic' concept of economic system development description (mostly by sine and cosine functions) has several critics. For instance following argument is known. The human knowledge development constantly brings partial and total innovations, which have profound economical and social consequences[8]. It can be hardly thought about any form of total innovations that do not lead to economical substitution. The initial point is accurate analysis of structural problem basic discrepancies. Saturation curves are mathematical description of substitution processes. Saturation curves are images of mathematical functions, which at its essentials are formulas of incremental quantities converging to zero. There are many forms of saturation curves. Saturation curves can follow all functions that converge to a constant value. Saturation 'S' curves are defined by monotone increasing increment up to reaching the extreme value, and then monotone decreasing increment. Any form of saturation curves with the shape of big 'S' can be in principle defined by composition of various partial functions. So called 'ecological function' are very inspirational. These functions describe a typical development of particular economical processes and systems, because the development of economical phenomena is often an analogy to biological processes[9].

When assessing both concepts (innovation theory and saturation curves) from critical view of contemporary entrepreneurship concepts and models (organic approach to enterprise, i.e. as spontaneous order), then it can be assumed, that the difference in description of innovation (economic) processes is rather econometric problem, then problem of entrepreneurship and enterprise theory.

On the other hand in both theories from the aspects of contemporary enterprise development we can point out that:

- the both above presented concepts are using task solution approach 'on the system' not 'in the system', i.e. describing the innovation process development in time and not the process causality;
- presented concepts perceive system structure in 'correlation', i.e. they define it as a function parameter drawn from correlation analysis and not as a definition (substantial) system parameter;
- presented concepts are not considering the relation between invention and innovation, i.e. system potential and system effects.

[8] H.D. Haustein: *Ekonomická prognóza.* Svoboda, Praha 1972, p. 153.
[9] Ibid., pp. 138-141, 155.

The opportunity to vault transcripts of innovation (economic) processes listed above to the form of internal causal model that accepts both approaches – innovation theory and concept of saturation 'S' curves, is given by contemporary concept of enterprise as a complex organism, based on theory of potentials, spontaneous order, bifurcation points, etc.

1. Innovation dynamics as a developmental potential of productive system

Contemporary 'organic' (holistic) concept of approach to enterprise and its development is based on several concepts.

The *first concept* deals with the relation between invention and innovation in entrepreneurship, i.e. the relation between entrepreneurial potential and its real manifestation. It is an association of two opposite existential principles of potentiality and reality. Total entrepreneurial potential (PC) is defined by sum of 'effective (or purposeful) potential' (U) that is transferring to real effective effect (E), 'expended potential' (VP) on attaining the real effect (E) and 'stabilized potential' (SP) that is not transferring in to real effect (E) and mass of resources (M) that has disengaged from 'expended potential' (VP). Thus, it is true that $PC_0 = U_0 + VP_0 + SP_0$, where lower index '0' marks beginning (initial) moment of potential generation. Further can be stated that, $VP_0 = M_1$, a $U_0 = E_1$where lower index '1' marks the following moment, when potential is transforming in to real manifestation, i.e. effect (E_1) and a mass of expended resources (M_1). As well can be assumed that, $U > 0$, $VP > 0$ and $SP > 0$. The term potential is perceived as any disposition of entrepreneurial subject (system). Used terms are explained in publications by Z. Mikoláš[10] in more detail.

If we generalize elementary principles of economic thought[11], we come to a relation $KPC_1 > \left[2 - \left(\frac{SP_0}{PC_0}\right)\right]$, where $KPC_1 = \frac{PC_1}{PC_0} > 1$.

Likewise the growth of effective and total potential is assumed. This assumption can be derived from natural and socio-psychological existential principles – living organisms tend to reproduction and human knowledge uncovers new natural and social potential that can be useful for extended reproduction of human society (e.g. theory of industrial curves describes the growth of new knowledge with exponential functions).

[10] Z. Mikoláš: *Jak zvýšit*…, op. cit.
[11] Ibid..; Idem: *Podnikání a podnik b.* VŠP, Ostrava 2006; Z. Mikoláš, J. Peterková, M. Tvrdíková: *Konkurenční potenciál průmyslového podniku*. C.H. Beck, Praha 2011.

Then it is possible to define further relations that follow up presented characteristic of the productive system potential development i.e., $KE_1 = \frac{KU_1}{KVP_1} > 1$, where KE_1 is the index of potential effective dynamics (effectiveness). Maintaining of productive system potential development dynamics is necessary condition, but not totally adequate. It is needed to define rational structure of partial components of the total potential. Two tendencies in economics are known – propensity to consume and propensity to safe. Analysis of given propensity to consume and save we can obtain principal and unique results, that were published in the book composed by Mikoláš, Peterková, Tvrdíková et al.[12]:

a) $KSC_0^* = \frac{SP_0}{PC_0} = 0{,}381966;$

b) $KUV_0^* = \frac{(U_0 : VP_0)}{PC_0} = 1 - KSC_0^* = 0{,}618034.$

The rational dynamics of two generations of productive system (enterprise) total potential in the 'golden section' is therefore defined with relation $KPC_1^{ZR} = 2 - KSC_0^* = 1 + KUV_0^* = 1{,}618034.$

The *second concept* deals with relation of change dynamics i.e. speed of innovation diffusion and it is based on the theory of spontaneous order that emphasizes the mechanism of potential transformation, called the 'flow of change'[13]. According to other relations it is obvious that system innovation (development) is possible only, if there exist two contradictions, i.e. two following potentials, effects, etc. Then it is based on assumption, that $E = v * M$. Quantity 'v' is the speed of changes, i.e. change frequency, so called system innovation process dynamics brought by relevant mass of resources (M). The general rules of system innovation process dynamics can be applied: $KE_1 = \frac{KU_1}{KVP_1} > 1$, then $KE_1 = \frac{v_2}{v_1} > 1$.

The *third concept* accepts the relativity of potential effect change dynamics of entrepreneurial systems. In this concept we can come to consideration about time-based economics of developing (organic) entrepreneurial system[14]. Conclusions of the theoretical research presented by Mikoláš, Peterková, Tvrdíková et al.[15] are coming to deduction, that the optimum of the innovation process dynamics is given by relation (called 'relative section') $v_1/v_2 = \frac{1}{\sqrt{2}}$. From listed above it is obvious that contemporary entrepreneurial environment characteris-

[12] Mathematical proofs are presented in this monograph. See: Ibid.
[13] Z. Mikoláš: *Jak zvýšit*…, op. cit.; Idem: *Podnikání a podnik*…, op. cit.; Z. Mikoláš, J. Peterková, M. Tvrdíková: Op. cit., pp. 143-191.
[14] Ibid.
[15] Z. Mikoláš, J. Peterková, M. Tvrdíková: Op. cit.

tics follow a trend (for following innovation series $i = 1, 2, 3, ...$) that can be described by decreasing function $g_{(i)} = \left(\frac{1}{\sqrt{2}}\right)^{i}$[16]. Presented process is an expression of competitive struggle of entrepreneurial subjects in entrepreneurial environment[17].

The *fourth concept* perceives entrepreneurial subject (system) as an organic complex, i.e. inside system, that is presented in this paper as a key concept of productive system (entrepreneurial subjects, i.e. enterprises) development[18].

According to Mikoláš, Peterková, Tvrdíková et al.[19] $PC_1 = \left[2 - \frac{SP_0}{PC_0}\right] * * PC_0$, i.e. $PC1 = PC_0 + (v_1 + 1) * M_1$, therefore the potential increment $dPC_{10} = PC_1 - PC_0 = (v_1 + 1) * M_1$. Research initiatives[20] proof, that we must examine the system from the developmental point of view, e.g. in which stage of development the enterprise (productive system) exists (see figure 1).

In the A-B stage effective (U) potential cannot reach the level of expended (VP) potential (productive system is 'loss making', is juvenile). In the next B-C stage is the system 'profitable', respectively the effective potential is higher than the expended one. In this second stage the generation of industrial system is born (enterprise daughter, respectively new entrepreneurial project). In the point C the maximum of difference between effective and expended potential is reached. Often in the following C-D stage the third generation of the system is born. Thus there exist three systems living next to each other 'grandfather-father-son'. The golden section of the growth between first and second generation occurs, when the first generation is in the point D, the second in point C, also in the natural ('healthy') organization comes to combination of synergy among three generations of productive systems (enterprises). IN the post-productive D-E stage is system becoming 'loss making' again, the system dies away. The end of exis-

[16] Upon the Theory of innovation and "Moore's law" we can argue in favour of the "relative section" concept. Moore (co-founder of Intel) claims that the data density doubles approximately every 18 months (according to current definition of Moore's Law) and costs fall twice. This is true for 40 years. From the "relative section" point of view is possible that the data density by 9months increases by factor $\sqrt{2}$ and costs fall 1: $\sqrt{2}$ ratio. So the "Moore's law" is complementary with "relative section" principle of production systems potential development.

[17] For more detail see Z. Mikoláš: *Jak zvýšit*…, op. cit.; Idem: *Podnikání a podnik*…, op. cit.; Z. Mikoláš, Z. Wozniaková, V. Gruberová: *Entrepreneurship in Modern Economy − Potential of Enterprise*. In: *SME and Entrepreneurship.* Vol. II. Ed. E. Lechman. 1st ed. Gdansk University of Technology Publishing House, Gdansk 2010.

[18] This concept is highlighted also on the contrary of persistent crisis in the global economy and loses of economical rationality of many enterprise's developments (that can be seen i.e. in the instability of securities markets).

[19] Z. Mikoláš, J. Peterková, M. Tvrdíková: Op. cit.

[20] That took place Faculty of Economics of Technical University of Ostrava (2005-2011).

tence does not often occur in the point E, but the system dissolves already in the D-E stage.

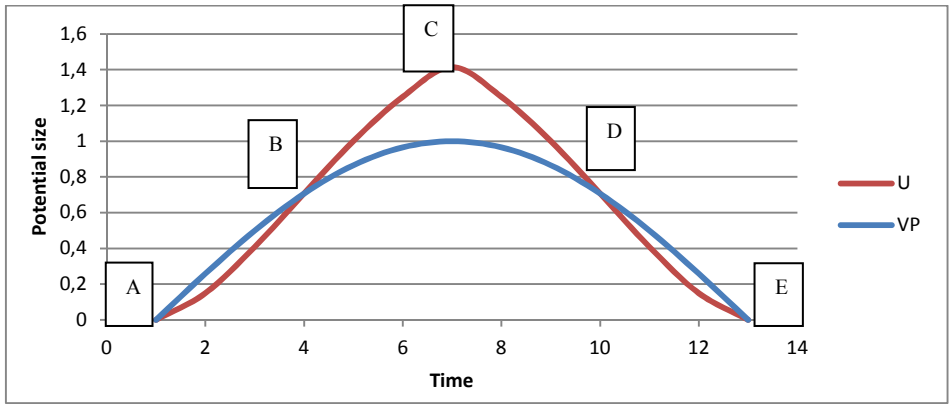

Figure 1. Simulation of U and VP[21]
Source: Based upon Z. Mikoláš, J. Peterková, M. Tvrdíková: *Konkurenční potenciál průmyslového podniku*. C.H. Beck, Praha 2011.

Considering the assumption from research work presented in the monograph by Mikoláš, Peterková, Tvrdíková et al.[22], we can enunciate an opinion that every productive system (enterprise) goes through typical limits (boundaries) of its evolution (see Figure 1):

a) the transition (break-even) point B of the pre-production stage to production stage of system existence;
b) the transition point D of the production stage to post-production stage.

These are typical characteristics for the ending precocious stage and for inception of the final stage of the productive system existence. Let's suppose that it is situation of spontaneous order of the productive system in theoretically ideal evolutionary stages then the first break-even point U_B is situated on the figure 1 in the instant time t_1 and the second point U_D is in instant time t_3.

Based on upon the previous text, a conclusion can me made that logically derived the pace of particular generation change, i.e. time moments, when the productive system second generation is born (related to development of the first generation), when he third generation comes up, etc. The second generation appears at the time, when the first generation is in the second evolution stage (i.e.

[21] Horizontal axis (independent variable) is denoted by time of productive systém existence (life cycle) and vertical axis (dependent variable) is denoted by potential size.
[22] Z. Mikoláš, J. Peterková, M. Tvrdíková et al.: Op. cit.

in the period between t_1 and t_2). Analogically the relation is valid for the third and the second generation, while the first generation of productive system appears in its third evolution stage (i.e. in time period between t_2 and t_3). Derived relations are compliant to elementary philosophical postulates – conformity and competition of three generations, when one negates the other. This follows a law of the negation of the negation that is fundamental of the natural and society evolution dialectic, therefore productive systems[23].

Researches also proof a theoretical thought, that productive systems (enterprises) all things considered normal, continuing generations grow following the 'golden section' rule (known from various sciences, e.g. biology), thus $\mathrm{KPC_i^{ZR}} = \frac{\mathrm{PC_i}}{\mathrm{PC_{i-1}}} = 1{,}61803$. This growth is given by th growth of productive system effectiveness in so called relative section $\mathrm{KE_{i-1}^{RR}} = \frac{\mathrm{v_i}}{\mathrm{v_{i-1}}} = \sqrt{2} = 1{,}4142135$, defined for $M_{i-1} = M_i$. So that the growth of the second generation opposed to first generation could come in to being following the 'golden section rule', then also the mass of resources of the second generation has to grow accordingly $KVP_{i-1}^{ZR} = \frac{M_i^{ZR}}{M_{i-1}} = 1{,}340423255$, thus the actual expended mass of resources in the 'golden section' donates a mass of resources expended in 'relative section' by 34,04%. This condition comes in to place under normal state, when the first productive system generation is situated at the point of evolution marked by D and the second generation just reached its development marked by C (see Figure 1).

It is worth to mention, that reproduction cycles (see Figure 1) are for various industries different. In mining industries (crude oil, iron ore, coal, etc.) are cycles or reproduction in hundreds of years, in agriculture, forestry or in water utilisation the principle developmental changes occur in tenths of years. In metallurgy, engineering, etc. are cycles about 10 to 20 or more years long. In electronics (semiconductor) industry we can speak about years.

Described relations and conditions of 'relative' and 'golden' sections are realized by change of economical and non-economical potentials. For example at first, strategic investment influences its environment positively not only economically or ecologically (often at the beginning there are some temporary negatives, such as ecological loads by its construction or by its testing run or entering the market is loss making, etc.), but positive changes occur in employment, improvement in regional environment, traffic infrastructure, etc. From the produc-

[23] For more detailed information and arguments look up the monograph Mikoláš, Peterková, Tvrdíková et. al. (2011).

tive system point of view, those are rational and effective non-economical outcomes (effects)! According to 'obsolete' economic concepts and beliefs it is an externality and therefore the economical profits are diminished due to lost opportunities! This contradiction of *'obsolete'* and in this presented paper *'new paradigms of economical approach'* is what we want to draw attention.

Conclusions

Previous claims only represent a trend to reach rationality of growth (evolution) of the productive systems (enterprises). Common affairs oscillate around subjective or objective causes along quantities, conditions and trends listed above. Tendencies to negentropy (order) and entropy (spontaneity) are changing. Understanding of these spontaneous order principles ('natural laws') by managers (i.e. economists and other competent individuals) increases the hope that productive systems and other real business complexes will avoid extreme crisis situations (that we are witnessing at the end of the first decade of the 21. century).

To sum up the previous pieces of knowledge from the paper, we coming to a conclusion, that rationality of productive system's (enterprises) transformation effectiveness goes through several key points. But this productive system development is not isolated, there has to be at least two competing systems to produce synergic effect from the 'unity and struggle of antitheses', e.g. two generations of productive systems. An enterprise network is created, where they 'compete in the frame of their cooperation' (e.g. the second generation descends the first one, but at the same time it competes with the latter and negates it) and simultaneously 'cooperate in the frame of their competition' (otherwise there would not produce synergic effect and spontaneous order of competing enterprises). Herewith it is necessary to perceive that the particular industries, regions, enterprises, etc. have different lengths of reproduction cycles, are in different stages of their existence, etc. Therefore simple and plain theorems are not sufficient. It is necessary to examine dilemmas of the genesis and extinction of the organic world, find the dialectic of organic, inorganic and artificial nature in coexistence with the human society. 'Relative and golden sections' occur in various objects and processes in different moments in time and even though they are related and implicate each other. It is crucial to recognize and compare incongruous and non-homogeneous phenomena. It is necessary to emphasize the eclectic and syncretistic approach in the science methodology, social science in particular. In

finding of harmony in diversities, unity in contrasts, quality in quantity, the beginning of the novel in the destruction of the old, the effect in potential, macro economical world in microeconomics and vice versa, etc., is the foundation of the new insight, that should be brought into economics, management theory or business.

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