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Lifecycle of enterprises and its dynamics: using fractal analogy model in empirical study of Czech and Slovak enterprises

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Abstract

The paper deals with the problematic of general enterprises’ lifecycle based on size (number of employees) as a parameter of growth and success. Author works with Miller and Friesen lifecycle model (Miller and Friesen, 1984) and expects occurrence of similar pattern in large scale sample composed from 677 randomly chosen companies of different type. This so cold “fractal analogy” will help to describe model lifecycle of general successful company in the terms of most significant time dependent phenomena observed on researched sample of Czech and Slovak enterprises. Except of mentioned model lifecycle characterization, which can be considered as main objective of the paper, there were three supplementary hypotheses tested. Questionnaire research as background of presented data was performed on Silesian University, School of Business Administration in Karvina, Czech Republic with the help of attendant bachelor's degree students. Presented paper includes brief literature review as well as most important research findings accompanied with commented charts, tables and discussion.

Keywords: Enterprise lifecycle, number of employees, timeline, questionnaire research, Czech and Slovak enterprises, fractal analogy

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1. Introduction

Lifecycle is generally important characteristic of any system. The cycle of life describes above all the length of life and dynamics of power changes in the course of life – continuous age of system. The vital parameters of system as size, energy, activity and success (can be characterized in many forms) generally rapidly rise after birth (star-up) and grow until maturity, when the system achieves maximal values of performance and integrity. After some period of best values are control and integrity reduced and the vital performance parameters decrease. Existence (life) exists until equilibrium of basic vital parameters is sustained and after this balance is broken, the existence of the system as individual entity ends and its components are dissembled to create new system order. From that point of view the length of lifecycle is a measure of sustainability. Universal lifecycle can be described by Gaussian-like curve.

The term lifecycle is often used also in economy and management context and can be related to many phenomena often as product, service, project, facility, technology, enterprise (firm, company), management, employee (human

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personality), macro economy and many more. There exist huge interconnection between different lifecycles in morphology and in cause and effect. Assessment of lifecycles is therefore always a challenge.

2. Literature Review And Hypotheses

The scientific literature evaluates organization lifecycle from very different viewpoints. There is discussed enterprise age with relation to size (Das, 1995; Brush, 1998; Cirillo, 2010 and Segarra, 2012), growth (Begley, 1995), performance (Coad, 2013), innovation and R&D (Huergo, 2004; Wöhrl, 2009), intangible resources (Anderson, 2013), and more. The lifecycle is related to management control (Granlund, 2005 and Silvola, 2008), compared with performance measurement (Garengo, 2007 and Vosloban, 2012), productivity (Halkos, 2007 and Hyytinen, 2012) and for example also franchise relations (Blut, 2011). Firm star-up lifecycle progression describes McAdam (2008), growth later is analyzed by Nichter (2010), high-growth by Delmar (2003), threshold periods by Palmer (2005) and theory of firm decline is contributed by Clementi (2010). To the modeling and simulation of corporate lifecycle dedicates Hu (2007) and Ayres (2002) addresses theme of ecology and economical effectiveness with the relation to lifecycle. The economic lifecycle from wider perspective describes Lee (2006) and adoption enterprise lifecycles in transition economies depicts Themistocleous (2011).

2.1. Phases of Enterprise Life Cycle

One of the most frequent models of the enterprise lifecycle, which was published by Danny Miller and Peter Friesen (Miller and Friesen, 1984), describes the mutual development of revenue (turnover) and expenses during the cycle in five phases:

1. Establishment (start-up) - there are only expenses, the company consumes the investment
2. Growth - expenses exceed revenues, the company is in loss
3. Stabilization (maturity) - revenues exceed expenses, the company is profitable
4. Crisis - incomes fall below the level of expenses, the company gets into loss
5. Termination - the company cannot handle the crisis, the loss is unbearable, business ends

Literature uses sometimes different names for labeling the phases, but the logic usually stays the same. The length of phases can be different and is dependent on many parameters such as branch of economic activity, competitive surroundings, economic environment, financial and intellectual capital of enterprise, innovation activity and more. Effects of new (innovated) business strategy on enterprise performance and lifecycle extension was characterized by Veselá and Šebestová as (i.) delay, (ii.) half-life, (iii.) activation, (iv.) reactionary and (v.) opposite (Veselá, Šebestová, 2012). As documented, phases 2, 3 and 4 can alternate and repeat several times.

Even if M-F model takes in account turnover and expenses as vital parameters to evaluate lifecycle phases, there is possible to relate it to other parameters as number of employees which we use in our study. Number of employees (headcount: annual work unit) as well as annual turnover or annual balance sheet total are parameters of enterprise size defined by European Commission dividing enterprises into micro, small, medium-sized and big (EC, 2003). Other vital parameters as for example profit, EVA or productivity or legal form are not taken in focus by this study, but are possibly evaluated by related scientific literature.

2.2. Parameters of Growth and Success and the Fractal Model

Although the model of Miller and Friesen (1984) was introduced for single enterprise, we suggest in our study to apply fractal analogy model approach (see Fig. 1).

Fractals are typically self-similar patterns, where self-similar means they are "the same from near as from far" (Gouyet, 1996) and are predominantly observed in natural sciences. Fractals may be exactly the same at every scale, or, they may be nearly the same at different scales (Mandelbrot, 1983). The usage of fractals in economics and enterprise behavior is rare, but documented (Canavesio, Martínez, 2007; Soliman, 1996). In our opinion the group of enterprises (macro perspective) should compose and reflect similar Gaussian-like pattern as single enterprise lifecycle (micro perspective).
Fig. 1: Research model of enterprises lifecycle using fractal analogy. Upper three small charts represent single enterprise in three phases of lifecycle different by age. Lower fourth big chart depicts large scale sections of Gaussian-like pattern reflecting single enterprise lifecycles. Axis $y$ intersects axis $x$ in the time of observation. (Source: own processing)

First three small charts on figure 1 represent enterprises in three phases (A, B and C) of lifecycle different by age. Enterprise type A represents young (after start-up) and small firm with tiny vital parameters (number of employees and turnover) but with great grow potential. This enterprise is expected to be mostly physical body as self-employed entrepreneur. Enterprise type B represents mature (stable) and medium firm with robust vital parameters (number of employees and turnover) but with small grow potential or even near threshold of some form of crisis. This enterprise is expected to be mostly legal body as limited liability company (LLC). Enterprise type C represents old (low integrity) and big firm with obscure (unclear) vital parameters (number of employees and turnover are expected high), with small or no grow potential or even in crisis falling into decline. This enterprise is expected to be mostly legal body as public liability company (PLC) or maybe limited liability company (LLC). This phase is mostly uncertain and conditional on innovation and reengineering activities, which only can prolong/reestablish the phase of maturity and good integrity. Without necessary escalated effort of innovation, reengineering and adaptation on emerging surrounding conditions crisis and decline are inevitable.

Important point is that enterprises (very all, even if maturity stage is not significantly apparent) transform in the course of time from type A to B and from B to C – this is the basic function of time, principle of growth, aging, maturation and lifecycle itself. Types A, B and C correspond so that to stages I., II. and III. and also roughly to 2, 3 and 4 of Miller-Friesen model. Terms small, medium and big do not necessarily comply with EC of SME definition (EC, 2003).
The highlight of fractal based analogy is in the fourth big chart on the figure 1, from where following hypotheses are derived. Three stages related to Miller-Friesen phases are suggested. Stage I is typical for high number/ percentage of enterprises type A – young enterprises. Stage II is typical for high number/ percentage of enterprises type B – mature enterprises and stage III is typical for high number/ percentage of enterprises type C – old enterprises. There is not clear how extensive in years are time periods of these stages; eventually the maxima numbers/ percentages of enterprise types A, B, C typical for these periods are the subject of research.

Following hypotheses regarding average number of employees in researched enterprises were formulated:

- **H1:** Number of employees tends to grow with the age of enterprise.
- **H2:** Younger (and small) enterprises tend to hire, while older (and bigger) companies tend to dismiss and reduce number of employees.
- **H3:** There exist general maxima – threshold age of stability for each size (number of employees) group.

### 3. Methodology

#### 3.1. Research Goal

The basic research goal is to draw up general lifecycle timeline dynamics (with the help of table 1) in the terms of most significant time dependent enterprise size phenomena, transforming successful enterprise of type A to B and to C, observed on researched sample of Czech and Slovak enterprises. Data background provided questionnaire research, particularly the questions on average number of employees and their change. More that suggested hypotheses are accepted/ dismissed in next chapters.

#### 3.2. Sample and Data Collection

Questionnaire research “Adaptability of entrepreneurship...” (II. round) was realized during spring semester 2012 by students of Business Entrepreneurship Faculty in Karvina, Silesian University in Opava (Czech Republic). 722 companies active in Czech and Slovak Republic in time period 2009-2011 were subjects of interest (SMEs are creating 89% of sample group in accordance with number of employees’ criterion). Interview protocol included controlled dialogue of a student with an enterprise owner, an executive manager or a top manager, so the collected data have the character of expert guess opinion. Company identification (10 questions) and identification of a student and his opinion on questionnaire relevance (5 questions) was necessary part of each form. Initial sample size 722 companies were filtered and reduced to 677 credible items. The questionnaire form also includes nondisclosure statement to provide business and privacy protection. Moreover data were analyzed anonymously and published as only no-name data.

Data reliability is assured (1) by authorization (contact person, signature, stamp), (2) by subjective student relevance evaluation, partially (3) by internet verification and (4) by statistical validity (Pearson correlation index).

Questionnaire was focused on seven areas of interest (3 of 61 questions evaluated in this paper):

- Enterprise identification (2 of 10 questions evaluated)
- Enterprise’s strategic management (6 questions)
- Economic and financial trends of business, risk management (11 questions),
- Personal politics of company (1 of 7 questions evaluated)
- Production, services and innovations (8 questions)
- Grants and subsidies (4 questions)
- Energetic and material savings and application of renewable sources (8 questions)
- Sustainability priorities of enterprises (7 questions)

There were evaluated following questions/criteria in presented paper. Numbering of questions correspond the one used in the questionnaire. Each areas of interest had a space for possible comment or further narrative explanation and information concerning asked questions.
Enterprise identification (part A):
- A3: The year of enterprise establishing (1989 to 2012)
- A7: Average number of employees in the years 2009-2011. (0, 1–10, 11–50, 51–100, 101–250, above 250)

Personal politics of company (part D):
- D3: How period 2009-2011 influenced number of employees? (growth more than 30%, growth up to 30%, no change, fall up to 30%, fall more than 30%)

Data were processed by Microsoft Excel® and IBM SPSS® software (Pearson correlation indices). Column diagrams and polynomial trend charts of third degree were calculated as a characterization of data groups wherefrom than maxima and minima were deduced. Charts and tables are presented and commented in following chapter. Analyses, results and discussion are presented later. Previous research results of the project “Adaptability of entrepreneurship…” were already presented in the scientific literature (Pawliczek, 2011; Pawliczek at al., 2011; Pawliczek, Piszczur, 2012, 2013; Rylková, Antonová 2012, Šebestová 2012 and Veselá, Šebestová, 2012).

4. Analyses, Results and Discussion

The chapter characterizes most important research results in four figures. All figures are x-y charts with time (age of enterprise or year of establishment) on x axis and percentage rate of data groups on y axis. Column diagrams are supplemented with scatter dot diagrams including polynomial trends. We care about data groups’ rates among each other in particular age (year) as well as we are interested in time difference in each data group alone. Some data are supported by correlation indices. Final table summarizes important time dependent phenomena of enterprises’ size (according number of employees) apparent in scatter dot diagrams.

4.1. Enterprise Age and Number of Employees

Fig.2: Enterprise age in years and number of employees’ group percentage. Circled numbers represent three higher values in each group.
(Source: own processing)
Figure 2 depicts frequency (percentage) of different number of employees’ (size) groups dependent on age of enterprise. White color represents no employees group, light gray 1 to 10 employees group (micro), gray 11 to 50 employees (small), dark gray 51 to 100 employees (medium I), 101 to 250 (medium II) employees and black more than 250 employees (big). Circled numbers represent three higher values in each group.

There is well apparent, that highest percentage of micro enterprises (0 to 10 employees) lies in time period of 1 to 11 years of age. On the other side highest percentage of big companies (above 250 employees) lies in time period of 18 to 24 years of age or more. Most of small and medium enterprises (11 to 250 employees) is somewhere in between 6 to 22 years of age.

![Graph showing enterprise year of establishment and number of employees.](image)

Supplementing previous figure 2, figure 3 offers slightly different view: year of establishment vs. number of employees’ rate. The lines represent polynomial trends of third degree and enable to determine minima or maxima.

We can clearly see that enterprises with no employees (self-employed entrepreneurs #1) and micro enterprises with 1 to 10 employees (#2) were mostly established (have maxima) close the year of observation (2012), so that they are enterprises of type A at the I. stage. Further we can observe that most of small enterprises with 11 to 50 employees (#7) and medium I enterprises group with 51 to 100 employees (#8) were established (have moderate maxima) in years 1996-1997 (they are 16 to 17 years old, or from wider point of view 14 to 19 years old). These enterprises we can designate as type B at stage II. The enterprises in groups of medium II enterprises with 101 to 250 employees (#12) and big enterprises with more than 250 employees (#14) were established (show maxima) mostly in the year 1989 or earlier (at socialist era of planed economy). We can classify them as type C at stage III.

In the light of presented findings we can clearly accept hypothesis H1: Higher age (earlier year of establishment) of enterprises brings higher rate of bigger enterprises or number of employees tends to grow with age of enterprise.

4.2. Enterprises Age and the Change in the Number of Employees

Figure 4 depicts influence of time period 2009 – 2011 on number of employees. Percentage (rate) of different
groups characterizing extent of change (axis y) is dependent on age of enterprise (axis x). White color represents group with number of employees growing more than 30%, light gray group with number of employees growing less than 30%, gray group with constant number of employees, dark gray group with number of employees falling less than 30% and black color group with number of employees falling more than 30%. Circled numbers represent three higher values in each group.

There is well apparent, that highest percentage of occupationally growing enterprises (more or less than 30%) lies in time period of 1 to 9 years of age, while highest percentage of enterprises growing more than 30% lies in time period of 2 to 7 years of age. On the other side highest percentage of dismissing companies (more or less than 30%) lies in time period of 5 to 24 years of age or more, while highest percentage of enterprises falling less than 30% lies in time period of 10 to 24 years of age. Surprisingly high value of employment fall (more than 30%) in 5th year of age can be explained with increased immature mortality of young enterprises. Some macro economical influences can be mirrored here too.

Fig. 4: Enterprise ages in years and influence of time period 2009-2011 on number of employees. Circled numbers represent three higher values in each group, except “no change” group. (Source: own processing)

Figure 5 follows the figure 4 and offers year of establishment vs. extent of change in number of employees. The lines represent polynomial trends of third degree and enable to determine minima or maxima.

We can see that most enterprises in group growing more than 30% (#4) were established (show maximum) around year 2008, so that they are approximately 5 years old (widely 4 to 6 years old). We can classify them as type A at stage I. Further most enterprises in group growing less than 30% (#5) were established (show maximum) around year 2005, so that are approximately 8 years old (widely 6 to 10 years old). We can classify them as type A or B at stage I or II. In other side we can see that most enterprises in group falling more than 30% (#9) were established (show insignificant maximum) around year 1995, so that they are approximately 17 years old (widely 15 to 20 years old). We can classify them as type C at stage III. Further most enterprises in group falling less than 30% (#11) were established (show maximum) in the year 1989 or earlier, so that they are approximately 24 or more years old. What is interesting, that in the same age (year of establishment 1989 or earlier) we indicate second weak maximum of growth (#13). There
is apparent the potential and effect of innovation, reengineering and reorganization here. We can classify them as type B or C at stage II. or III. The curve of “no change” (stability) shows two maxima at age of newborn and 19 years old. These periods show most stable behavior. The minimum is around 9 years of age – this period shows most turbulent behavior.

![Figure 5: Enterprise year of establishment and influence of time period 2009-2011 on number of employees including phenomena numbers corresponding to table 1. (Source: own processing)](image)

At the point of hypothesis H2: Younger (and small) enterprises tend to hire, while older (and bigger) companies tend to dismiss and reduce number of employees, we can accept this hypothesis regarding presented results. To enforce these results, there were 2-tailed Pearson correlation indices calculated significant at the 0.01 level:

- The results have shown, that highest correlation indicated group Medium II with 101 to 250 employees which correlates with index 0.865 to fall less than 30%.
- Second highest correlation indicated group Small with 11 to 50 employees which correlates with index 0.827 to “no change”.
- Third highest correlation indicated group Micro with 1 to 10 employees which correlates with index 0.783 to grow up to 30%.
- Fourth highest correlation indicated group Big with over 250 employees which correlates with index 0.761 to grow up to 30% (compare to phenomenon #13).

All presented results show very high correlation level and support acceptance of hypothesis H2.

5. Conclusion

5.1. Lifetime Dynamics

Observed phenomena encourage in construction of transparent table characterizing general model of successful enterprise lifecycle and its dynamics (see table 1). The table summarizes phenomena seen in previous figures 2 to 5 and matches it with stages I., II. and III. from figure 1.
The first stage of low employment and strong growth potential is according our empirical research since newborn to 4 – 5 years of enterprise age long. Second stage of medium employment and moderate growth is in period roughly from 5 to 19 years of enterprise age long. Third stage of high employment and fall is in period approximately 15 to 24 or more years of enterprise age. The borders between stages are very uncertain. Further growth as an effect of revitalization can occur in the III. stage and extend lifecycle of enterprise challenged with the danger of crisis.

Table 1: General enterprise lifetime dynamics – analytical overview of phenomena regarding number of employees’ parameter of enterprise size apparent on timeline. Stages of model lifecycle are in accordance to figure 1. (Source: own processing)

<table>
<thead>
<tr>
<th>#</th>
<th>Age (years)</th>
<th>Influence on number of employees</th>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt; 1 (0 to 4)</td>
<td>No employees group maximum</td>
<td>I.</td>
</tr>
<tr>
<td>2</td>
<td>&lt; 1 (0 to 4)</td>
<td>1 to 10 employees group maximum</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>&lt; 1 (0 to 4)</td>
<td>Stable number of employees (no change) group maximum</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>~ 5 (4 to 6)</td>
<td>Growth more than 30% group maximum</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>~ 8 (6 to 10)</td>
<td>Growth up to 30% group maximum</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>8 to 9</td>
<td>No change group minimum (dynamic change period)</td>
<td>II.</td>
</tr>
<tr>
<td>7</td>
<td>16 to 17 (14 to 19)</td>
<td>11 to 50 employees group maximum</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>14 to 19</td>
<td>51 to 100 employees group maximum</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>15 to 20</td>
<td>Fall more than 30% group maximum</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>18 to 20</td>
<td>No change group second maximum</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>&gt; 24</td>
<td>Fall up to 30% group maximum</td>
<td>III.</td>
</tr>
<tr>
<td>12</td>
<td>&gt; 24</td>
<td>101 to 250 employees group maximum</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>&gt; 24</td>
<td>Growth more than 30% group second maximum</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>&gt; 24</td>
<td>More than 250 employees group maximum</td>
<td></td>
</tr>
</tbody>
</table>

With the help of table 1 we can verify the validity of hypothesis H3: There exist general maxima – threshold age of stability for each size (number of employees) group:
- No employees group maximum (#1) is at the age of newborn, enterprises tend later to hire (stage I.)
- 1 to 10 employees group maximum (#2) is at the age of newborn, enterprises tend later to hire (stage I.)
- 11 to 50 employees group maximum (#7) is at the age 16 to 17, enterprises tend to dismiss (stage II.)
- 51 to 100 employees group maximum (#8) is at the age 14 to 19, enterprises tend to dismiss (stage II.)
- 101 to 250 employees group maximum (#12) is at the age of 24 or more, maxima not discovered (stage III.)
- Over 250 employees group maximum (#14) is at the age of 24 or more, maxima not discovered (stage III.)

Due to groups of Medium II (101 to 250 employees) and Big (over 250 employees) whose maxima we have not indicated (due to limited observation period since 1989) we have to reformulate hypothesis H3.

The paper brought new interesting attitude and empirical data composed into model lifecycle based on dynamics of employment phenomena occurring in extensive sample of Czech and Slovak enterprises. Suggested hypotheses were tested. Presented lifecycle model nevertheless of its simplifications and limitations brings unique analytical results due to fractal analogy approach rarely seen in related scientific literature. Further research and analyses using the fractal analogy based on data of enterprises’ turnover and legal status will be performed later, so that comparison to results based on number of employees could be done. Author sincerely encourages scientific audience for feedback.

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