INNOVATIVE ENVIRONMENT FOR BUSINESS DEVELOPMENT

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Abstract

Innovativeness is one of the main determinants for a company's development and when searching for the correlation between innovativeness and development one needs to apply quantative measures. This work includes a model for a company's assessment in its technology and environment innovative aspects. The concept of quantative assessment of environment is presented through determining innovation structure and coming up with a general innovation index. It is an important element in creating a diagnostic tool to be applied in the area of innovativeness and development interdependences.

Key words: Technological innovativeness, innovative environment

Introduction

European Union policy confirms the key role of innovativeness in developmental processes. '*The strategy for smart and balanced development ensuring social inclusion'* within *Europe 2020 Strategy*, among other targets, highlights intelligent development through economic growth based on knowledge and innovation. In order to implement this strategy, the European Commission put forward flagship initiatives which include:

'*Innovation Union' – a project to improve framework conditions and access to research and innovation funds, in order to turn innovative ideas into new products and services, which, as a consequence, will contribute to economic growth and boosting employment.* [Strategy, 2010]

The terms innovation, innovative company and innovativeness are therefore regarded as synonymous for development, hence the justification for operations which will result in the effective application of innovativeness in a company's development process.

Innovativeness and a company's development

Applying the rule that a company's innovativeness is a factor that ensures its development, allows one to conclude (applying Zeroth-order logic) and present the correlation between innovativeness and a company's development. Introducing the symbols (R, W, F) and ascribing them simple sentences:

- Rule (R) – A company's innovativeness is a factor in ensuring its development,
- Condition (W) – Researched company is innovative,
- Facts (F) – Researched company is developing,

We can, using connectives of conjunction and implication create three complex sentences corresponding to three types of logic:

- Deductive logic (concluding):

$$(R \land W) \rightarrow F$$

"*If a company's innovativeness is a factor ensuring its development and the researched company is innovative then the researched company is developing.*"

The truth function of premises (*R* and *W*) guarantees the truth function of conclusion (*F*).

- Inductive logic (concluding):

$$(W \land F) \rightarrow R$$

"*If the researched company is innovative and is developing then the company's innovativeness is the factor which determines its development.*"

The truth function of premises (*W* and *F*) does not guarantee the truth function of conclusion (*R*). A company's development is a fact possible to confirm unequivocally. Nevertheless, other innovative premises in a company's development may also occur. Thanks to the observation and research of a large number of companies it is possible to prove the validity of the implication pointed out by the inductive reasoning and may also validate the hypothesis that a company's innovativeness is a factor ensuring its development.

- Abductive logic (concluding) [Urbański, 2009]:

$$(F \land R) \rightarrow W$$

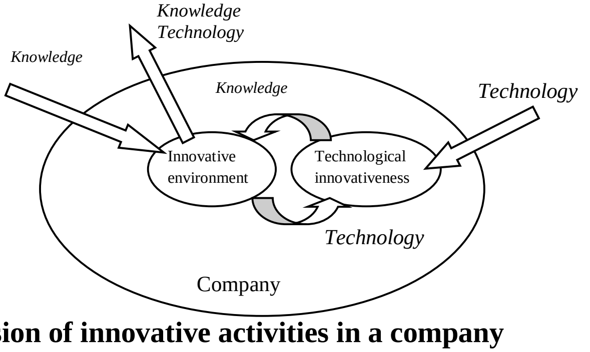
"*If the researched company is developing and its innovativeness is a factor in ensuring its development then the observed company in innovative.*"

The truth function of premises (F and R) does not also guarantee the truth function of conclusion (W). Similarly to the above case, a company's development is a fact that can be unequivocally confirmed. However, there can be other premises apart from innovativeness in a company's development. Showing through observations and research conducted on a large number of companies the truth function of implications pointed out by the abductive logic, may validate the hypothesis that a company's innovativeness is the main factor ensuring its development. Presenting the interpretation of the abductive conclusion results in this different form, one may assert that it is difficult to find a company that is developing without being innovative.

The empirical research into the truth functions of indicated types of logic requires the application of a company's development and innovative measures. In the case of development, such measures are well known and commonplace, for example a wide range of growth measures [Motyka, 2011]. However, currently applied, mainly bi-state, innovation measures [for example, statistical research, research according to OSLO Handbook], while useful in other cases, here appear insufficient. Therefore, there are justified attempts to extend the range of a company's innovation assessment methods, applying multi-state or continuous measures which will contribute to the creation of a diagnostic tool applied in the area of innovativeness and development interdependencies.

Types of innovative activities in a company

The main aim of a company's operations is to sell its goods and services. This generates revenue, which is indicated as the main goal in the classic model or increasing a company's market value, which is its aim according to the modern theory of company development. In a company, one can perceive innovativeness as directly linked to products and their manufacturing techniques as well as manufacturing techniques in the process of service implementation [Jasiński, 2008; Matusiak 2008]. This is technological innovativeness which considers product features as well as the features of manufacturing techniques [Zehner, 2008]. The remaining company operations and features create the innovative environment [System…, 2011]. Graph 1 shows the position of technological innovativeness and the innovative environment within a company.



Graph 1. Division of innovative activities in a company

Source: Own work.

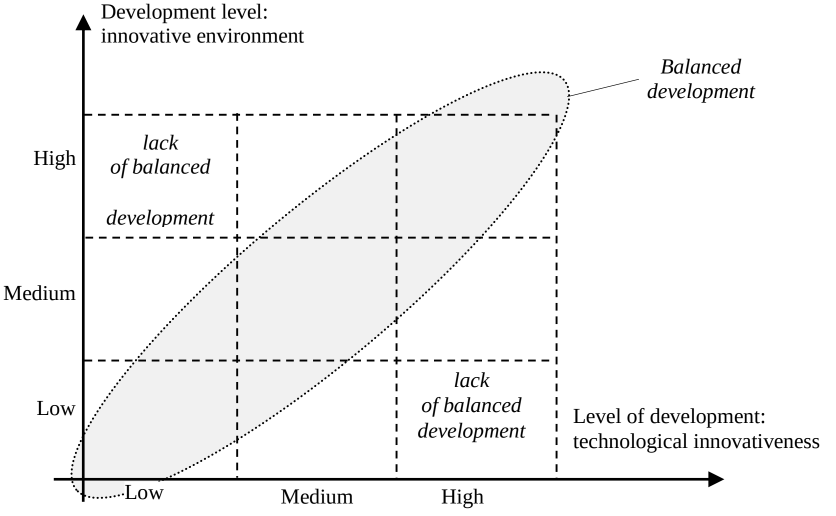
An innovative environment boosts technological innovativeness through the implementation of new technologies (products or manufacturing methods). At the same time, an innovative environment draws from technological innovation knowledge, which stimulates its development. Technological innovativeness is also empowered externally, through new technologies acquisition. An innovative environment draws from outside, ensuring its development but it can also transmit (sell) knowledge or technologies to the outside world [Frąckowiak, 2004].

For example, an innovation which is protected by a patent was created in an innovative environment as a result of research conducted. This is an element of innovative environment development; however it does not impact the revenue or increase a company's value [Mard, 2000; Hitchner, Mard, 2003]. The commercialisation of this innovation, namely boosting technological innovativeness or external sales will affect the revenue or increase a company's value [Trzmielak, 2013]. Another example is the purchase by a company of technologies (machinery, product manufacturing methods), which boosts technological innovativeness [Klincewicz, 2001]. Understanding of the purchased new technology empowers with knowledge the innovative environment, thereby stimulating its development. The cooperation between companies and the scientific personnel of universities may serve as an example of knowledge transfer from outside a company towards an innovative environment [Hsu, et al., 2008].

An innovative environment and a company's technological innovativeness occur at different developmental levels, which may be presented using a state-transition matrix (Graph 2) [Kaczmarska, 2009; Kaczmarska, 2010; Kaczmarska, Gierulski, 2012]. In the matrix, the company is represented by the coordinates of a point corresponding to the development level of technological innovativeness and the innovative environment. The location of the point on the matrix surface requires the establishment of continuous measures for both coordinates[30].

In the matrix of innovative states one can point to three areas in which development levels of technological innovativeness and the innovative environment are balanced, and the remaining parts of the matrix are the areas of domination or the lack of balanced development.

[30] In the case of technological innovativeness such measures were suggested in the works of: [Gierulski et al., 2013; Gierulski, Kaczmarska, 2013].



Graph 2. Company innovativeness states matrix
Source: Own work.

The above matrix may serve as a basis for the construction of a diagnostic tool of the current innovative state of a company along with an indication of the operation directions which foster beneficial changes.

Innovative environment structure

Innovative environment structure shows the layout of innovative activities arranged according to the degree of innovation. In place of the frequently applied bi-state assessment – innovative or non-innovative environment – a discrete multi-state scale has been applied. An operation division into two classes has been introduced: conservative operations and innovative operations. Each class is split into three areas, depending on the intensity of the assessed feature. This has given rise to the creation of six zones (as in [Gierulski et al., 2013; Gierulski, Kaczmarska, 2013] connected to the ascribed level of their innovation (Table 1.).

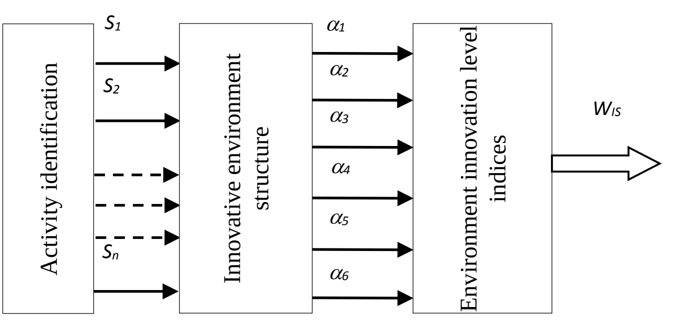
Table 1. Zone of innovative environment level

No. zone	Environment class	Innovative level zones	
		Operations	Measure
1	Conservative	Definite conservative	α_1
2		Medium conservative	α_2
3		Moderate conservative	α_3
4	Innovative	Moderate innovative	α_4
5		Medium innovative	α_5
6		Definite innovative	α_6

Source: Own work based on [Gierulski et al. 2013].

Innovation level assessment must be ascribed to one of the six zones. The first zone includes definite conservative operations within the innovative environment. Innovation features here are almost non-existent or invisible. The innovative features in further zones become ever more intense, up to the sixth zone where it is definitely dominant.

The research into innovative environment structure is conducted in two stages (Graph 3.). The first identifies activities ($S_1 \ldots S_n$) and ascribes them to the innovation level zones. The second determines the values of innovation structure coefficient α (Table 1.), which are the measure of participation of the zone activities in an innovative environment, expressed in percent.



Graph 3. Research into innovative environment structure

Source: Own work.

Based on the indicated values of structure coefficients, α is calculated as a value of the general index of environment innovativeness (W_{IS}), as a function of implemented operations in that environment.

$$W_{IS} = f(\alpha_1 \dots \alpha_6)$$

$$\alpha_k = f(S_1 \dots S_n)$$

where: *k = 1…6,* *n* – the number of identified activities within an innovative environment.

The index can be calculated applying the centre of gravity method with weighted coefficients

[Kaczmarska, Gierulski, 2012]. The role of the weighted coefficients is to strengthen the activities at the higher innovation levels in the overall environment assessment. In accordance with this method for the linear weighted coefficient, the general innovation index of the environment is calculated following the formula:

$$W_{IS} = \frac{\sum_{k=1}^{6} k \cdot (k \cdot \alpha_k)}{\sum_{k=1}^{6} (k \cdot \alpha_k)}$$

where: $k = 1 \dots 6$ – number of innovation level interval

α_k – coefficient values of innovative environment structure.

The lowest value of the general innovation index calculated in such a manner equals 1 and the highest stands at 6. It is a closed interval <1;6> with the extension equalling 5. The location within the interval denotes the percentage index calculated according to the following correlation:

$$W_{IS}^{\%} = \frac{W_{IS} - 1}{5} \cdot 100\%$$

The general innovation index of the environment is a one-parameter overall assessment established based on the structure determined by coefficient α.

Measurement methodology

The information on the innovative environment is collected though the interview method using a special research form. The form includes each innovation zone to which five activities are attached, including one that is undetermined and is linked to the specifics of the researched company. The assessment employs Likert Scale (0, 1, 2, 3, 4, 5), which determines the intensity of activities. Data gained in such a manner is sufficient to determine the structure of the innovative environment and calculate the general innovation index.

Research form data for each innovation zone provide five number values that denote the intensity of individual activities. Expressing this data as coefficients:

$$\vartheta_{k,i} \quad k = 1 \dots 6, \quad i = 1 \dots 5$$

Where: k – numerator of innovation zones,
i – numerator of activities in zones

The received data can be presented in a matrix of innovation level coefficients:

$$[\vartheta]_{6,5} = \begin{bmatrix} \vartheta_{1,1} & \vartheta_{1,2} & \vartheta_{1,3} & \vartheta_{1,4} & \vartheta_{1,5} \\ \vartheta_{2,1} & \vartheta_{2,2} & \vartheta_{2,3} & \vartheta_{2,4} & \vartheta_{2,5} \\ \dots & \dots & \dots & \dots & \dots \\ \vartheta_{6,1} & \vartheta_{6,2} & \vartheta_{6,3} & \vartheta_{6,4} & \vartheta_{6,5} \end{bmatrix}$$

Two column matrixes have been introduced in order to perform calculations:

$$[V]_{5,1} = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix} \qquad [J]_{6,1} = \begin{bmatrix} 1 \\ 1 \\ 1 \\ 1 \\ 1 \\ 1 \end{bmatrix}$$

Innovation structure can be determined using absolute and relative measures. Company innovation structure is determined applying absolute measure by coefficients $\alpha*$ which take the values from the interval <0;20>. The matrix of coefficients denotes the following correlation:

$$[\alpha^*]_{6,1} = [\vartheta]_{6,5} \cdot [V]_{5,1}$$

Relative measure shows percentage of activities in individual innovation zones applying normalised correlation coefficients α.

$$[\alpha]_{6,1} = \frac{[\alpha^*]_{6,1}}{[\alpha^*]_{1,6}^T \cdot [J]_{6,1}} \, 100\%$$

Coefficients α allow the calculation of the value of the general innovation index of the environment in the above presented manner.

Examples of analysis results

Two companies were the subject of the analysis for which the values of structure coefficients were determined on the basis of available knowledge on the products, applied manufacturing methods, and other company operations.

Company P1 – a medium-sized iron foundry which specialises in sewage goods. It also offers non-standard mouldings utilised in the machinery building industry. Their products undergo a resistance test (α_6 = 0.2). The company's own team of constructors cooperate with scientific centres which facilitates moulding processes computer simulations (α_5 = 0.2). Modern automatic moulding flasks, castings, moulds, cleaning and painting lines are implemented. Moreover, they run training on production automation, drawing from the experiences of other iron foundries. The production relies on the process approach (α_4 = 0.3). Cast iron stoves feature air intake systems with dedusting devices. The plant also produces basic goods using traditional methods. The foundry introduced a quality management system that adheres to ISO 9000 (α_3 = 0.1) and runs basic health and safety training (α_1 = 0.1). Traditional IT systems (α_2 = 0.1) are applied in management.

Company P2 – from the chemical sector, produces flexographic paints (utilised in printing) and cardboard, paper and wood glues. A section of production focuses on traditional products. There is a possibility to modify products to meet customer requirements. The eco-aspect in paint production (α_3 = 0.3) is taken into account. The company is attempting to launch cutting edge products in the area of flexographic paints through cooperation with external laboratories (α_5 = 0.1). Transfer of technologies (α_4 = 0.1) also takes place. The company runs basic health and safety training and applies a traditional quality control system (α_1 = 0.2). Quality mismanagement occurs at the level of basic training. The structure of the company is functional and the IT management support systems traditional (α_2 = 0.3).

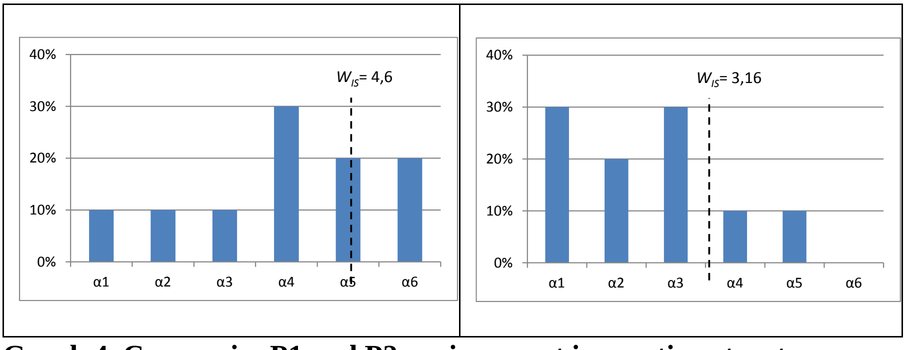
Table 2. shows the data and the analysis results for the examples of P1 and P2. The results in graphic form are shown in Graph 4.

Most of company P1's activities are considered innovative (α_4, α_5, α_6), the conservative operations occur to a lesser degree, which is reflected in the low values of coefficients α_1, α_2, α_3. The general innovation index for the environment stands at 4,6, which gives the value of 72%. This is a significant index value, which proves the high level of environment innovativeness. Unlike in company P2, where the majority of actions are of a conservative nature. The general innovation index stands at 3,16 which is 43,2%. Such results point to the medium level of innovative environment in this company.

Table 2. Examples of data and results

Company	Coefficients of structure						Indices	
	α_1	α_2	α_3	α_4	α_5	α_6	W_{IS}	$W_{IS}\%$
P1	0.1	0.1	0.1	0.3	0.2	0.2	4.6	72%
P2	0.3	0.2	0.3	0.1	0.1	0	3.16	43.2%

Source: Own work.



Graph 4. Companies P1 and P2 environment innovation structure.

Source: Own work

Conclusions

According to statistical data, the dynamics of E.U. development as a whole is in decline, which is linked to the drop in the pace of innovation growth. Therefore, it is necessary to investigate the reasons for this negative trend, which may provide tools facilitating development activities. Based on a quantative approach applied in quality management (Six Sigma), according to which, measurement is the basis for assessment, it seems valid to come up with a methodology for measuring a company's innovativeness in the aspect of its development. The methodology presented in this work adheres to this view. The quantative continuous measures in two complimentary areas: technological innovativeness and the innovativeness of the environment, constitute a solid foundation for the creation of a diagnostic tool which will enable the indication of individualised actions for boosting development.

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