

ECONOBOTICS – OPERATIONAL MODELS OF THE ENTERPRISES COMPETITIVENESS

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Abstract. *The competitiveness management is one of the most important and critical process in an enterprise, that has, as a main goal, the global quality implementation according to which the enterprise becomes a leader in its external environment, and has strong implications on the markets, society, and upon the natural environment,*

Thus, in the context of the econobotic framework introduced and defined in [1] and specified in [2] the present paper will develop the fundamental specific operational models that will be used in the analysis and design of the enterprise's evolution for global quality and competitiveness.

According to the TSE – space definition as the competitiveness space, the concepts and representations of the enterprise's existence will be identified, and the models regarding competitiveness orientation and location, and actions will be developed.

The determined models represent the context for analysis and strategies design regarding the evolution of the enterprise in its complex external environment, in a manner that considers its behavior from the point of view of competitiveness and global quality.

Keywords: *econobotics, competitiveness, enterprises evolution, competitiveness orientation, competitiveness location, econobotic actions.*

1. Introduction

Considering the enterprise's competitiveness goal as the global quality implementation according to the specific directions (see [3]), results that the competitiveness management will be considered and developed at the specific physical, biological, human, social, technical and economic econobotics reality levels [2].

In this context the existence and competitiveness position of the enterprise in the external and internal environments are of interest in establishing the strategies and actions of the management in a proactive manner, and in designing its functions, structures and interactions for short, medium and long terms. The corresponding decisions are supported by different models, mainly economic, and by simulations.

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The econobotic approach considers the enterprise as an econobotic system characterized by complexity, heterogeneity, and governed by synergistic relations and interactions that evolves in the TSE – space. From this point of view, the econobotic model of the competitiveness evolution for the enterprise will be developed as analysis and decisional support for the competitiveness management.

2. Concepts and models of the enterprise’s existence and competitiveness in the TSE – space

For the TSE – space context defined in [2] and assigned to the external environment, results that the enterprise’s existence is expressed by its internal TSE – space as in figure 1.

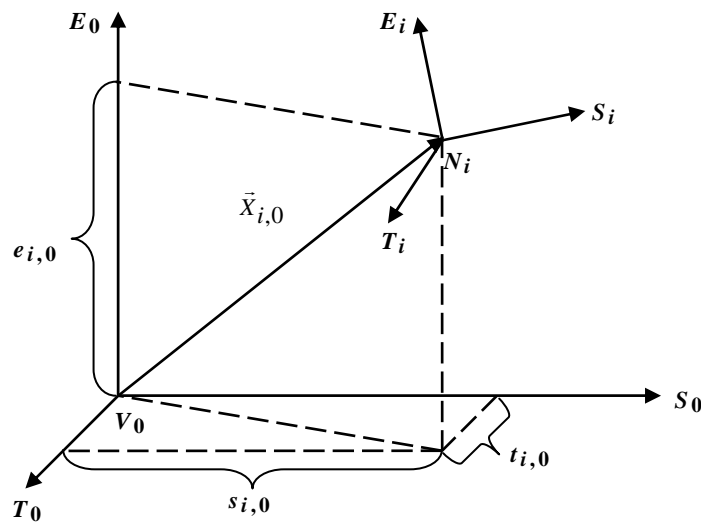


Figure 1. The enterprise’s existence in the external competitiveness space. $V_0 T_0 S_0 E_0 = \{V_0\}$ – the external TSE – space; N_i – enterprise i in the TSE – space $\{V_0\}$; $N_i T_i S_i E_i = \{N_i\}$ – the internal TSE – space of the enterprise’s existence; $\bar{X}_{i,0}$ – the position vector of the enterprise in the competitiveness space.

In the context of figure 1, the econobotic concepts and elements attached to the model of the enterprise’s existence are determined as following:

a) The position vector $\vec{X}_{i,0}$ relative to $\{V_0\}$ is determined by the column matrix of the homogeneous coordinates of the enterprise in the external TSE – space, $\{V_0\}$, as:

$$[X]_{i,0} = \begin{bmatrix} t_{i,0} \\ s_{i,0} \\ e_{i,0} \\ 1 \end{bmatrix} = [t_{i,0} \quad s_{i,0} \quad e_{i,0} \quad 1]^T. \quad (1)$$

b) The **orientation** of the internal TSE – space $\{N_i\}$ relative to the external one $\{V_0\}$ is determined by the **orientation matrix** expressed in homogeneous coordinates:

$$[O]_{i,0} = \begin{bmatrix} \overline{\cos(T_0, T_i)} & \overline{\cos(T_0, S_i)} & \overline{\cos(T_0, E_i)} & 0 \\ \overline{\cos(S_0, T_i)} & \overline{\cos(S_0, S_i)} & \overline{\cos(S_0, E_i)} & 0 \\ \overline{\cos(E_0, T_i)} & \overline{\cos(E_0, S_i)} & \overline{\cos(E_0, E_i)} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} \theta_{1/i} & \theta_{2/i} & \theta_{3/i} & 0 \\ \sigma_{1/i} & \sigma_{2/i} & \sigma_{3/i} & 0 \\ \varepsilon_{1/i} & \varepsilon_{2/i} & \varepsilon_{3/i} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, \quad (2)$$

where $(\overline{\Lambda_0, \Gamma_i})$ with $\Lambda = T, S, E$ and $\Gamma = T, S, E$ represent the orientation angles between two axis of $\{V_0\}$ and respectively, $\{N_i\}$.

The $(\overline{\Lambda_0, \Gamma_i})$ angles with $\Lambda = \Gamma$ represent technical, social, and economic orientations of the enterprise relative to the ones considered as reference in the external environment, and the $(\overline{\Lambda_0, \Gamma_i})$ angles with $\Lambda \neq \Gamma$ represent the corresponding influences upon the other dimensions of the internal TSE – space, $\{N_i\}$, relative to the external one, $\{V_0\}$.

c) The **location** of the enterprise in the external competitiveness space is determined by the **competitiveness matrix** $[C]_{i,0}$ that integrates both the orientation of the internal TSE – space $\{N_i\}$ relative to the external one $\{V_0\}$, and its position in $\{V_0\}$, as following:

$$[C]_{i,0} = \begin{bmatrix} \theta_{1/i} & \theta_{2/i} & \theta_{3/i} & t_{i,0} \\ \sigma_{1/i} & \sigma_{2/i} & \sigma_{3/i} & s_{i,0} \\ \varepsilon_{1/i} & \varepsilon_{2/i} & \varepsilon_{3/i} & e_{i,0} \\ 0 & 0 & 0 & 1 \end{bmatrix}. \quad (3)$$

The $[C]_{i,0}$ matrix represents how the enterprise's competitiveness is perceived by the external environment.

Also, a $[C]_{0,i} = [C]_{i,0}^{-1}$ matrix will represent how the competitiveness space is represented by the enterprise at its internal TSE – space level, and is determined according to (2) and (3) by the following relation:

$$[C]_{i,0} = \begin{bmatrix} \cos(\overline{T_i, T_o}) & \cos(\overline{T_i, S_o}) & \cos(\overline{T_i, E_o}) & t_{0,i} \\ \cos(\overline{S_i, T_o}) & \cos(\overline{S_i, S_o}) & \cos(\overline{S_i, E_o}) & s_{0,i} \\ \cos(\overline{E_i, T_o}) & \cos(\overline{E_i, S_o}) & \cos(\overline{E_i, E_o}) & e_{0,i} \\ 0 & 0 & 0 & 1 \end{bmatrix} =$$

$$= \begin{bmatrix} \theta_{1/i} & \sigma_{1/i} & \varepsilon_{1/i} & -(\theta_{1/i} \cdot t_{i,0} + \sigma_{1/i} \cdot s_{i,0} + \varepsilon_{1/i} \cdot e_{i,0}) \\ \theta_{2/i} & \sigma_{2/i} & \varepsilon_{2/i} & -(\theta_{2/i} \cdot t_{i,0} + \sigma_{2/i} \cdot s_{i,0} + \varepsilon_{2/i} \cdot e_{i,0}) \\ \theta_{3/i} & \sigma_{3/i} & \varepsilon_{3/i} & -(\theta_{3/i} \cdot t_{i,0} + \sigma_{3/i} \cdot s_{i,0} + \varepsilon_{3/i} \cdot e_{i,0}) \\ 0 & 0 & 0 & 1 \end{bmatrix}. \quad (4)$$

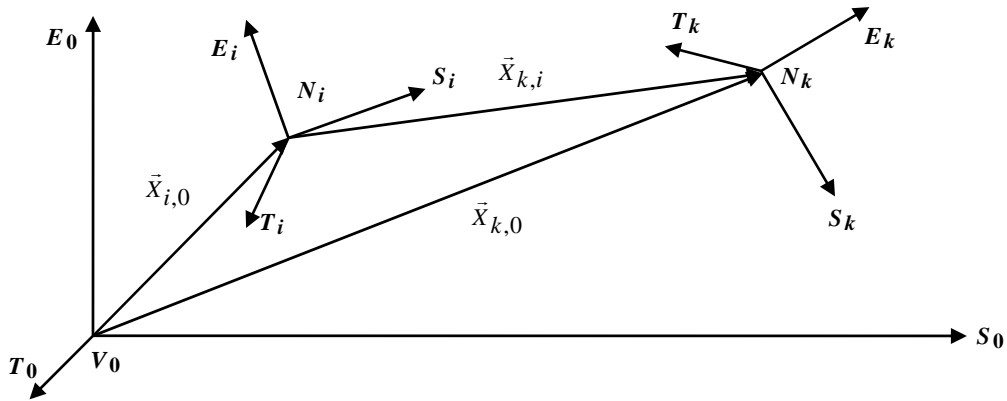


Figure 2. The competition configuration between the enterprises $\{N_i\}$ and $\{N_k\}$.

The competition configuration between two enterprises is represented in figure 2 and is determined by the relative competitiveness location in the TSE – space:

$$[C]_{k,i} = \begin{bmatrix} \theta_{1/k,i} & \theta_{2/k,i} & \theta_{3/k,i} & t_{k,i} \\ \sigma_{1/k,i} & \sigma_{2/k,i} & \sigma_{3/k,i} & s_{k,i} \\ \varepsilon_{1/k,i} & \varepsilon_{2/k,i} & \varepsilon_{3/k,i} & e_{k,i} \\ 0 & 0 & 0 & 1 \end{bmatrix}, \quad (5)$$

where $\theta_{v/k,i} = \overline{\cos(T_i, \Gamma_k)}$, $\sigma_{v/k,i} = \overline{\cos(S_i, \Gamma_k)}$, $\varepsilon_{v/k,i} = \overline{\cos(E_i, \Gamma_k)}$ for $v=1,2,3$, and $\Gamma_k = T_k, S_k, E_k$ determine the orientation of the enterprise $\{N_k\}$ relative to $\{N_i\}$, and $[X]_{k,i} = [t_{k,i} \ s_{k,i} \ e_{k,i} \ 1]^T$ is the position of $\{N_k\}$ relative to $\{N_i\}$, expressed in homogeneous coordinates.

Applying relation (4), the competitiveness location of $\{N_i\}$ relative to $\{N_k\}$ will be determined as:

$$[C]_{i,k} = \begin{bmatrix} \theta_{1/k,i} & \sigma_{1/k,i} & \varepsilon_{1/k,i} & t_{i,k} \\ \theta_{2/k,i} & \sigma_{2/k,i} & \varepsilon_{2/k,i} & s_{i,k} \\ \theta_{3/k,i} & \sigma_{3/k,i} & \varepsilon_{3/k,i} & e_{i,k} \\ 0 & 0 & 0 & 1 \end{bmatrix}, \quad (6)$$

with the position of N_i relative to $\{N_k\}$ expressed in normal coordinates for a 3-D space given by the position vector $[N_i]_k = [t_{i,k} \ s_{i,k} \ e_{i,k}]^T$, where:

$$\begin{cases} t_{i,k} = -(\theta_{1/k,i} \cdot t_{k,i} + \sigma_{1/k,i} \cdot s_{k,i} + \varepsilon_{1/k,i} \cdot e_{k,i}) \\ s_{i,k} = -(\theta_{2/k,i} \cdot t_{k,i} + \sigma_{2/k,i} \cdot s_{k,i} + \varepsilon_{2/k,i} \cdot e_{k,i}) \\ e_{i,k} = -(\theta_{3/k,i} \cdot t_{k,i} + \sigma_{3/k,i} \cdot s_{k,i} + \varepsilon_{3/k,i} \cdot e_{k,i}). \end{cases}$$

The relative competitiveness locations $[C]_{k,i}$, $[C]_{p,k}$ for three enterprises N_i, N_k, N_p are, composed in the $[C]_{p,i}$ competitiveness location of $\{N_p\}$ relative to $\{N_i\}$, determined with the relation:

$$[C]_{p,i} = [C]_{k,i} \cdot [C]_{p,k}. \quad (7)$$

The ‘absolute’ competitiveness location of $\{N_p\}$ in the universe (i.e., external environment) $\{V_0\}$ is determined by:

$$[C]_{p,0} = [C]_{i,0} \cdot [C]_{p,i}. \quad (8)$$

Relations (7) and (8) are generalized for any number of enterprises N_1, N_2, \dots, N_n as following:

$$[C]_{n,1} = [C]_{2,1} \cdot [C]_{3,2} \cdot \dots \cdot [C]_{n,n-1} = \prod_{k=1}^{n-1} [C]_{k+1,k}, \quad (9)$$

and respectively:

$$[C]_{n,0} = [C]_{1,0} \cdot [C]_{n,1} = [C]_{1,0} \cdot [C]_{2,1} \cdot [C]_{3,2} \cdot \dots \cdot [C]_{n,n-1} = \prod_{k=0}^{n-1} [C]_{k+1,k}. \quad (10)$$

3. The action – oriented model of the enterprise

The objectives and decisions of the enterprise are integrated and expressed by its actions in the TSE – space. From this point of view, the following elementary actions are determined as in table 1, such that any evolution instance or trajectory is a composition of a number of successive elementary actions.

Table 1.

Elementary actions in the TSE – space.

1. Social – economic competitiveness orientation (SEO)	
	$[C_i]_{\tau+1,\tau} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos \alpha & -\sin \alpha & 0 \\ 0 & \sin \alpha & \cos \alpha & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$
2. Technical – economic competitiveness orientation (TEO)	
	$[C_i]_{\tau+1,\tau} = \begin{bmatrix} \cos \beta & 0 & \sin \beta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin \beta & 0 & \cos \beta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

3. Technical – social competitiveness orientation (TSO)	
<p style="text-align: center;">CPO – conventional positive orientation</p>	$[C_i]_{\tau+1,\tau} = \begin{bmatrix} \cos \gamma & -\sin \gamma & 0 & 0 \\ \sin \gamma & \cos \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$
4. Technical competitiveness (positive or negative) evolution (P/N-TE)	
	$[C_i]_{\tau+1,\tau} = \begin{bmatrix} 1 & 0 & 0 & a \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$
5. Social competitiveness (positive or negative) evolution (P/N-SE)	
	$[C_i]_{\tau+1,\tau} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & b \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$
6. Economic competitiveness (positive or negative) evolution (P/N-EE)	
	$[C_i]_{\tau+1,\tau} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & c \\ 0 & 0 & 0 & 1 \end{bmatrix}$

7. General competitiveness orientation (GEO)	
	$[C_i]_{\tau+1,\tau} = \begin{bmatrix} \theta_{1/\tau+1,\tau} & \theta_{2/\tau+1,\tau} & \theta_{3/\tau+1,\tau} \\ \sigma_{1/\tau+1,\tau} & \sigma_{2/\tau+1,\tau} & \sigma_{3/\tau+1,\tau} \\ \varepsilon_{1/\tau+1,\tau} & \varepsilon_{2/\tau+1,\tau} & \varepsilon_{3/\tau+1,\tau} \\ 0 & 0 & 0 \end{bmatrix}$
8. General competitiveness (positive or negative) evolution (P/N-GE)	
	$[C_i]_{\tau+1,\tau} = \begin{bmatrix} 1 & 0 & 0 & a \\ 0 & 1 & 0 & b \\ 0 & 0 & 1 & c \\ 0 & 0 & 0 & 1 \end{bmatrix}$
9. General competitiveness orientation and evolution (GCOE)	
	$[C_i]_{\tau+1,\tau} = \begin{bmatrix} \theta_{1/\tau+1,\tau} & \theta_{2/\tau+1,\tau} & \theta_{3/\tau+1,\tau} \\ \sigma_{1/\tau+1,\tau} & \sigma_{2/\tau+1,\tau} & \sigma_{3/\tau+1,\tau} \\ \varepsilon_{1/\tau+1,\tau} & \varepsilon_{2/\tau+1,\tau} & \varepsilon_{3/\tau+1,\tau} \\ 0 & 0 & 0 \end{bmatrix}$

Any action is specified as $A_{\tau+1} = (c_{\tau+1}, w_{\tau+1}, f_{\tau+1})$, where $c_{\tau+1}$ represents the initial conditions given by the last location of the enterprise, $\{N_i(\tau)\}$, $w_{\tau+1}$ – the contents of the action (i.e., orientation, evolution, or different combinations), $f_{\tau+1}$ – the effect of the action given by $[C_i]_{\tau+1,\tau}$ that determines the new location $\{N_i(\tau+1)\}$. In this context, an action $A_{\tau+1}$ is a transition from $\{N_i(\tau)\}$ to $\{N_i(\tau+1)\}$, and is represented by:

$$\{N_i(\tau)\} \xrightarrow{A_{\tau+1}} \{N_i(\tau+1)\}. \quad (11)$$

A succession of actions defined as:

$$\{N_i(\tau)\} \xrightarrow{A_{\tau+1}} \{N_i(\tau+1)\} \xrightarrow{A_{\tau+2}} \{N_i(\tau+2)\} \rightarrow \dots \rightarrow \{N_i(\tau+n-1)\} \xrightarrow{A_{\tau+n}} \{N_i(\tau+n)\} \quad (12)$$

will be represented by a composed action

$$A(\tau \rightarrow \tau+n) = A_{\tau+1} \circ A_{\tau+2} \circ \dots \circ A_{\tau+n}, \quad (13)$$

and its global effect relative to the initial internal TSE – space of the enterprise, $\{N_i(\tau)\}$, will be given by the matrix:

$$[C_i]_{\tau+n,\tau} = [C_i]_{\tau+1,\tau} \cdot [C_i]_{\tau+2,\tau+1} \cdot \dots \cdot [C_i]_{\tau+n,\tau+n-1} = \prod_{k=0}^{n-1} [C_i]_{\tau+k+1,\tau+k}, \quad (14)$$

where $[C_i]_{\tau+k+1,\tau+k}$, $k = 0, n-1$ is the effect matrix of action $A_{\tau+k+1}$.

Matrix $[C_i]_{\tau+n,\tau}$ will determine the final competitiveness location of the enterprise after the n actions, relative to its initial location, $\{N_i(\tau)\}$, and applying relation (10), the final location of the enterprise in the competitiveness space $\{V_0\}$ will be given by:

$$[C_i]_{\tau+n,0} = [C_i]_{\tau,0} \cdot [C_i]_{\tau+n,\tau} = [C_i]_{i,0} \cdot [C_i]_{\tau+n,\tau}, \quad (15)$$

where $[C_i]_{\tau,0} = [C]_{i,0}$ represents the initial location of the enterprise $\{N_i(\tau)\} = \{N_i\}$ relative to $\{V_0\}$.

Relations (12) ÷ (15) and table 1 define the **competitiveness action – oriented model** of the enterprise, that supports the analysis and design of the competitiveness strategies in attaining a goal expressed as a location in the TSE – space, by determining the corresponding and necessary actions.

4. Analysis case for an enterprise in the TSE – space

In figure 3, the successive effect locations of an enterprise N_1 are considered after the following actions: A_1 – positive technical evolution with a units advance relative to its initial competitiveness location $\{N_1(\tau)\}$, after which N_1 attains the competitiveness location $\{N_1(\tau+1)\}$ determined by $[C_1]_{\tau+1,\tau}$, A_2 – general evolution with $[0 \ b \ c]^T$ and technical – social competitiveness orientation with $\gamma = 45^\circ$ relative to its competitiveness

location $\{N_1(\tau+1)\}$, after which N_1 attains the final competitiveness location $\{N_1(\tau+2)\}$ determined by $[C_1]_{\tau+2,\tau+1}$, where:

$$[C_1]_{\tau+1,\tau} = \begin{bmatrix} 1 & 0 & 0 & a \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}; \quad [C_1]_{\tau+2,\tau+1} = \begin{bmatrix} \sqrt{2}/2 & -\sqrt{2}/2 & 0 & 0 \\ \sqrt{2}/2 & \sqrt{2}/2 & 0 & b \\ 0 & 0 & 1 & c \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

Applying the competitiveness action – oriented model developed in §3 the competitiveness location of the enterprise in its external TSE – space after actions A_1 and A_2 is given by:

$$[C_1]_{\tau+2,\tau} = [C_1]_{\tau+1,\tau} \cdot [C_1]_{\tau+2,\tau+1} = \begin{bmatrix} \sqrt{2}/2 & -\sqrt{2}/2 & 0 & a \\ \sqrt{2}/2 & \sqrt{2}/2 & 0 & b \\ 0 & 0 & 1 & c \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

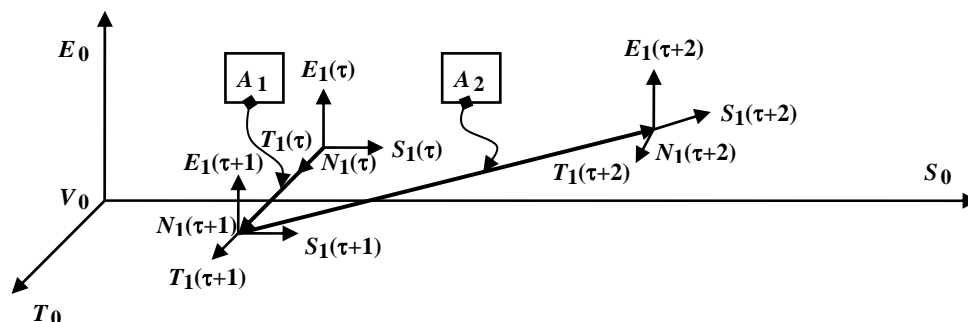


Figure 3. The competitiveness locations of the enterprise $\{N_1\}$ after actions A_1 and A_2 .

5. Conclusions

The presented paper extends the field of *econobotics* defined and introduced in [1, 2] by developing the concepts and models of the enterprise's existence and competitiveness in the TSE – space. In this context the behavior of the enterprise is expressed by its actions in the competitiveness space and, accordingly, the *competitiveness action – oriented model* is developed.

The results create the framework for analysis and design of the enterprise's strategies and behaviors in its external environment in a

competitiveness oriented manner. From this point of view, an analysis case has been developed as an example of the action – oriented model direct application.

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