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Using Evolutionary Algorithms to Promote Sustainable Collaboration Networks through Partner Selection

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Abstract. A Collaborative Network (CN), usually arises to achieve a large number of innovations in a short term, by sharing and developing information and competencies, from the interaction of a group of partners involved here. Despite its potential, there are some challenges on deploying this concept into practice, particularly when the purpose is to choose the suitable partner to promote sustainable CNs, regarding the following dimensions of sustainability; Social, Economic and Environment.

Given the lack of methods existent on literature, in this work we propose an approach, which uses multicriteria decision method integrated with evolutionary algorithms (NSGA II) to provide suitable partners for a CN, regarding the three dimensions referred before.

The approach developed here, will be further applied into a real situation, based on an existent CN, in order to provide it with suitable partners, promoting therefore its sustainability over different perspectives.

Keywords: Sustainability, Collaborative Networks, Partner's selection, Multicriteria Decision-Making, Evolutionary Algorithms

1 Introduction

Achieving a suitable partner, considering a diversity of knowledge areas to be accounted, is essential to obtain a successful collaborative ecosystem [1-2].

The last developments, regarding business intelligence, brought many applications for professional use, with some of them, being used by human resource professionals to seek adequate partners to define a project's team [1].

However, and despite such achievements, which includes the increase in requirements within SMEs on behalf of social and environmental responsibilities, there are a lack of approaches that allows to support the manager's board on partner's assessment-based criteria, and regarding the three well known sustainability's vectors/dimensions, namely; Economic, Social and Environmental [3].

Therefore, we propose a decision support approach to provide suitable partners for a Collaborative Network (CN) on behalf of the three dimensions referred before.

The framework developed here, uses multicriteria integrated with Multi-Attribute Value Theory (MAVT) methods, and on behalf of the three sustainable dimensions. The decision space, resulted, is then explored by NSGA II in order to find the maximum aggregated value added for a given CN's process, where a set of individual ones are further obtained, concerning each partner's position to be fulfilled, related to each activity.

In addition, the priorities regarding the relative importance, concerning each one of the 3 dimensions, are also considered here, through the use of AHP method.

The obtained results show the versatility of using evolutionary algorithms such as NSGA II, on achieving feasible and alternative solutions, which allows to face contingencies, that might be arise (e.g., resignation of some "elected" candidates to fulfill the partner's position).

The model proposed in this work, will be assessed in terms of its robustness, by using a real situation, relied on a sustainable product, which is developed on behalf of a CN context.

2 Literature Review

An increasingly number of works from the literature, highlights the importance of the collaborative networks, as a mean to rump up SMEs competitiveness, through the innovation achieved through the share of competencies and resources with other partners, on pursuing a common goal such as the development of a new products [3-4].

Furthermore, the share of information and knowledge with other SMEs, and on behalf of the collaborative networks, has allowed to develop certain skills including expertise among the staff of each SMS's partner involved [5-6].

Additionally, some studies found on literature (e.g.[1][7]), states that the high levels of innovation achieved from collaborative networks (CN), is somehow associated with the partner's selection, concerning each activity and process to be considered.

A diversity of studies, focused on partner's selection approaches, has been performed, to increase the CN's innovative performance, with most of them, analyzing the

CN created, on behalf of different perspectives such as knowledge relevance (e.g.[6]), key CN available roles (e.g.[8-9]), external assets (e.g. [9-10]), external cooperation to create new competences or knowledge related to the development of new products (e.g. [10]), between others.

Other works, use Social Networks theory (SN) to map the demanded external assets for SMEs (e.g. [11]). Other works, uses SN to identify expert individuals to be integrated as partners (e.g. [3][10]).

However, and despite the existence of such studies, there are an absence of approaches that includes sustainable development requirements, increasingly demanded from the SMEs by the society of “today”, as well as by the society of “tomorrow”.

3 Proposed Approach

3.1 Model’s Conceptual Architecture

The approach presented in this section, intends to support the management board of a Collaborative Network (CN), who wants to assess and select a (a set of) of candidates to be partner(s) for an (a set of) activity (ies), related to a (a set of) process(es) on behalf of a CN (Figure1).

Each set of candidates (C_{ij}), were previous selected according to a set of CN’s pre-requirements and they are related to a given partner’s position j , concerning an activity (a_j), which is associated to a given process (n) of the product to be developed. Each set, is associated to a set of possible alternative solutions to be considered, where one solution from each set, will be further selected, relied on the CN’s needs and preferences, joined with the correspondent priorities, related to each sustainability’s vector. Fig.1, presents the developed approach.

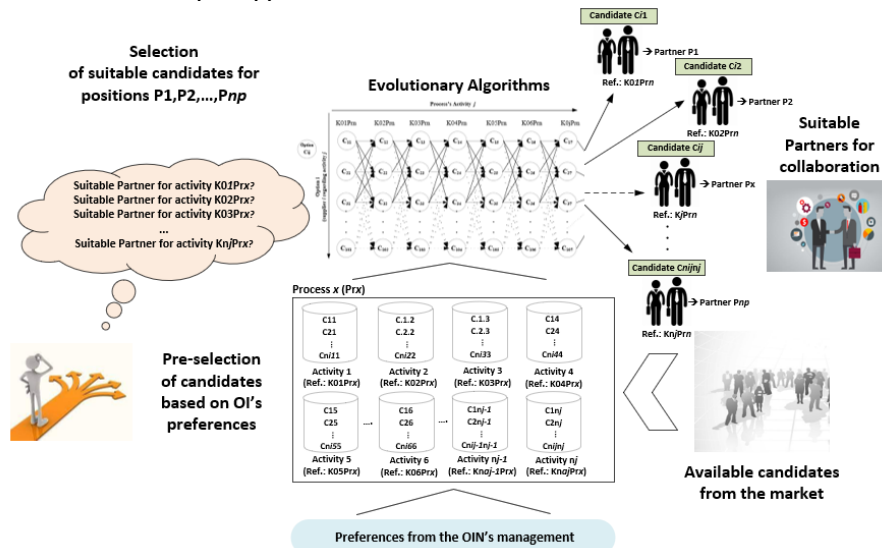


Fig. 1. Model’s architecture

Through the observation of Fig. 1, the 1st phase begins with a pre-selection of a set of partner's candidates (x_{ij}) from the market, which is performed according to a set of pre-requirements to be attended, such as the proximity degree, the compliance with the project deadlines, scope and costs, among other factors considered here.

The multi criteria used here, on behalf of the tree dimensions of sustainability, allows to classify each partner's candidate C_{ij} , in order to reduce the decision space, by considering only the candidates, fitted to the needs of collaborative network created here, increasing at the same time the NSGAI's efficiency on getting feasible solutions in less time.

3.2 Criteria Used and Problem's Formulation

The partner's selection for the same CN, arises multiple challenges, especially when it's intended to promote sustainability within the CN itself on developing such products/systems.

According to [12-13], sustainability actions, can be splatted in Social, Economic and Environmental.

Through the literature about partner's selection, it was reached a set of criteria on behalf of the 3 dimensions created before, namely;

- Environmental → Regards all the factors that could have an impact on the CN's environmental viability, such as those that are primarily related to the organization's environmental responsibility [3][5], such as the accreditation for environmental standards, self-energy Greenhouse Gas (GHG) emissions, circular economy policies, soil and water quality, among others.
- Economic → Regarding the CN's financial viability and economics. This includes issues relating to the economic well-being of organization [4][6], such as the supply chain's channels (distribution nodes, transport types/modes, etc.), financial situation as well as the credibility attached to it, operation costs, facility's place, scale (available) of operations, the capacity of facilities, the reliability of feedstock supply, among other related criteria involved.
- Social → Relates to all the criteria that could have an impact on the CN's social viability, including problems that are primarily related to the social wellbeing of the organization's stakeholders [6][12-13], the reputation at stake as well as the knowledge/information sharing concerns, including work conditions, accessibility to knowledge and information sharing, knowledge relevance, reputation, and the number of relationships established with other organizations, among other criteria involved.

Based on that criterion, it was developed a framework to analyze and evaluate each candidate to be included in a CN with concerns to the three dimensions considered before (Table 1), i.e.: ω -Social, λ -Economics and θ -Environmental.

Table 1. Adopted criteria on behalf of the 3 known sustainability’s dimensions

Dimension: Economics (λ)		Dimension: Social (ω)		Dimension: Environmental (θ)	
Designation	Ref.	Designation	Ref.	Designation	Ref.
Financial situation and credibility	$\lambda 1$	Company’s reputation (Transparency)	$\omega 1$	Industry’s energy dependence level from fossil fuels	$\theta 1$
Available assets (€)	$\lambda 2$	Knowledge relevance	$\omega 2$	Compliance with legal requirements regarding environment	$\theta 2$
Facility’s location	$\lambda 3$	Work conditions	$\omega 3$	Circular economy policies	$\theta 3$
Supply chain’s channels	$\lambda 4$	External available resources (social network)	$\omega 4$	Environmental standards compliance (accreditation)	$\theta 4$
Availability degree (flexibility) to scale operations	$\lambda 5$	Social responsibility	$\omega 5$		
Operations costs to complete the activity/task (€)	$\lambda 6$	Average deadline to complete activity/task (months)	$\omega 6$		
Available funds (€)	$\lambda 7$	Quality perceived on developing the activities/tasks	$\omega 7$		

Based on each sub criteria/attribute presented on Table 1, it was defined a decision variable ($c_{ij}^{(D_j)}$), regarding each partner’s candidate i , related to a given process activity j . This variable is defined based on each sub criteria/attribute τ , associated to each activity j and sustainable dimension j (θ -Environment, λ –Economical and ω - Social), namely:

$$D = \{\lambda, \omega, \theta\} \wedge j = \{1, 2, \dots, 7\} \wedge \tau = \{\{1, 2, \dots, n_\lambda\} \cup \{1, 2, \dots, n_\omega\} \cup \{1, 2, \dots, n_\theta\}\} \wedge n_\lambda, n_\omega, n_\theta, \tau, j \in \square \quad (1)$$

Based on this notation and through criteria shown on Table 1, it can be established a decision-variable related to each attribute ($c_{ij}^{(D_j)}$), which can be further aggregated into a pay-off table, according to the activity which is demanding for a new partner position, on behalf of process x ($K_i Pr x$) (Table 2 a).

In order to convert each attribute’s value to the same unit’s scale ($v_{ij}^{D_j}(c_{ij}^{(D_j)})$), we’ve used the MAVT approach, to uniformize the unit’s scale of the attributes involved, by using the following expression:

$$c_{ij}^{(D_j)} \longrightarrow \left(\frac{|c_{ij}^{(D_j)} - c_{ij(worst)}^{(D_j)}|}{|c_{ij(best)}^{(D_j)} - c_{ij(worst)}^{(D_j)}|} \right) \longrightarrow v_{ij}^{(D_j)}(c_{ij}^{(D_j)}) \quad (2)$$

Table 2 intends to show an example of a table respectively for all $c_{ij}^{(D_j)}$ and $v_{ij}^{D_j}(c_{ij}^{(D_j)})$ values.

Table 2. Example of a pay-off table regarding an activity i , related to project j (Ki Pr j): (a) $c_{ij}^{(D\tau)}$; (b) $v_{ij}^{D\tau}(c_{ij}^{(D\tau)})$.

$c_{i\tau}^{D\tau}$	$\lambda 1$	$\lambda 2$	...	λn_λ	$\omega 1$	$\omega 2$	...	ωn_ω	$\theta 1$	$\theta 2$	...	θn_θ
C_1	$c_{11}^{\lambda 1}$	$c_{12}^{\lambda 2}$	...	$c_{1\lambda}^{\lambda n_\lambda}$	$c_{11}^{\omega 1}$	$c_{12}^{\omega 2}$	...	$c_{1\omega}^{\omega n_\omega}$	$c_{11}^{\theta 1}$	$c_{12}^{\theta 2}$	...	$c_{1\theta}^{\theta n_\theta}$
C_2	$c_{21}^{\lambda 1}$	$c_{22}^{\lambda 2}$	...	$c_{2\lambda}^{\lambda n_\lambda}$	$c_{21}^{\omega 1}$	$c_{22}^{\omega 2}$	...	$c_{2\omega}^{\omega n_\omega}$	$c_{21}^{\theta 1}$	$c_{22}^{\theta 2}$	...	$c_{2\theta}^{\theta n_\theta}$
...
C_n	$c_{n1}^{\lambda 1}$	$c_{n2}^{\lambda 2}$	...	$c_{n\lambda}^{\lambda n_\lambda}$	$c_{n1}^{\omega 1}$	$c_{n2}^{\omega 2}$	...	$c_{n\omega}^{\omega n_\omega}$	$c_{n1}^{\theta 1}$	$c_{n2}^{\theta 2}$	...	$c_{n\theta}^{\theta n_\theta}$

a)

$v_{i\tau}^{D\tau}(c_{i\tau}^{D\tau})$	$\lambda 1$	$\lambda 2$	...	λn_λ	$\omega 1$	$\omega 2$	...	ωn	$\theta 1$	$\theta 2$	...	θn
c_1	$v_{11}^{\lambda 1}(c_{11}^{\lambda 1})$	$v_{12}^{\lambda 2}(c_{12}^{\lambda 2})$	...	$v_{1\lambda}^{\lambda n_\lambda}(c_{1\lambda}^{\lambda n_\lambda})$	$v_{11}^{\omega 1}(c_{11}^{\omega 1})$	$v_{12}^{\omega 2}(c_{12}^{\omega 2})$	...	$v_{1\omega}^{\omega n_\omega}(c_{1\omega}^{\omega n_\omega})$	$v_{11}^{\theta 1}(c_{11}^{\theta 1})$	$v_{12}^{\theta 2}(c_{12}^{\theta 2})$	...	$v_{1\theta}^{\theta n_\theta}(c_{1\theta}^{\theta n_\theta})$
c_2	$v_{21}^{\lambda 1}(c_{21}^{\lambda 1})$	$v_{22}^{\lambda 2}(c_{22}^{\lambda 2})$	...	$v_{2\lambda}^{\lambda n_\lambda}(c_{2\lambda}^{\lambda n_\lambda})$	$v_{21}^{\omega 1}(c_{21}^{\omega 1})$	$v_{22}^{\omega 2}(c_{22}^{\omega 2})$	...	$v_{2\omega}^{\omega n_\omega}(c_{2\omega}^{\omega n_\omega})$	$v_{21}^{\theta 1}(c_{21}^{\theta 1})$	$v_{22}^{\theta 2}(c_{22}^{\theta 2})$	...	$v_{2\theta}^{\theta n_\theta}(c_{2\theta}^{\theta n_\theta})$
...
c_n	$v_{n1}^{\lambda 1}(c_{n1}^{\lambda 1})$	$v_{n2}^{\lambda 2}(c_{n2}^{\lambda 2})$	...	$v_{n\lambda}^{\lambda n_\lambda}(c_{n\lambda}^{\lambda n_\lambda})$	$v_{n1}^{\omega 1}(c_{n1}^{\omega 1})$	$v_{n2}^{\omega 2}(c_{n2}^{\omega 2})$	...	$v_{n\omega}^{\omega n_\omega}(c_{n\omega}^{\omega n_\omega})$	$v_{n1}^{\theta 1}(c_{n1}^{\theta 1})$	$v_{n2}^{\theta 2}(c_{n2}^{\theta 2})$	...	$v_{n\theta}^{\theta n_\theta}(c_{n\theta}^{\theta n_\theta})$

b)

In order to classify each candidate c_{ij} , according to its overall value, based on the value functions $V_{ij}^\lambda(C_{ij}^\lambda)$, $V_{ij}^\omega(C_{ij}^\omega)$ and $V_{ij}^\theta(C_{ij}^\theta)$, considered for each sustainability's dimension D , it was used an additive MAVT model, by aggregating each individual attribute's values ($v_{i\tau}^{D\tau}(c_{i\tau}^{(D\tau)})$) for each activity j .

In order to obtain the overall function value ($V_{ij}(C_{ij})$), used to rank each partner's candidate, a same approach was conducted, by aggregating those values, according to their relative importance, which is expressed by a correspondent factor (α_D), considered for each sustainability's dimension D , i.e.:

$$V_i(C_i) = V_{ij}(V_{ij}^\lambda(c_{ij}^\lambda), V_{ij}^\omega(c_{ij}^\omega), V_{ij}^\theta(c_{ij}^\theta)) = \alpha_\lambda \cdot V_{ij}^\lambda(c_{ij}^\lambda) + \alpha_\omega \cdot V_{ij}^\omega(c_{ij}^\omega) + \alpha_\theta \cdot V_{ij}^\theta(c_{ij}^\theta) \quad (3)$$

Each factor α_D ($\alpha_\lambda, \alpha_\omega, \alpha_\theta$) are obtained by using the Analytical Hierarchical Process (AHP) framework [10], and through the inquiries, conducted to the management board.

Thus, and based on (3), it is obtained the overall objective function to be maximized, composed by individual objectives functions, each associated to a sustainability's dimension.

$$\begin{aligned} \max \quad & V^D(c^D), & w/D &= \lambda, \omega, \theta \\ \text{subject to } & c \in C & w/V^D(c^D) &= [V^\lambda(c^\lambda), V^\omega(c^\omega), V^\theta(c^\theta)]^T \end{aligned} \quad (4)$$

$$V^D(c^D) = \sum_{j=1}^{n_j} \sum_{\tau=1}^{n_D} v_{j\tau}(c_{j\tau}^{(D,\tau)}) \quad w/D = \{\lambda, \omega, \theta\} \wedge v_{j\tau}(c_{j\tau}^{(D,\tau)}) \wedge n_j, n_D, \tau, j \in \square \quad (5)$$

Where $V_i^\lambda(C_i^\lambda)$, $V_i^\omega(C_i^\omega)$ and $V_i^\theta(C_i^\theta)$ can be obtained by:

$$Economic: \max V_i^\lambda (c_i^\lambda) = \sum_{j=1}^{n_i} \sum_{\tau=1}^{n_j} v_{ij\tau} (c_{ij\tau}^{\lambda_\tau}) \tag{6}$$

$$Social: \max V_i^\omega (c_i^\omega) = \sum_{j=1}^{n_i} \sum_{\tau=1}^{n_\omega} v_{ij\tau} (c_{ij\tau}^{\omega_\tau}) \tag{7}$$

$$Environmental: \max V_i^\theta (c_i^\theta) = \sum_{j=1}^{n_i} \sum_{\tau=1}^{n_\theta} (v_{ij\tau} (c_{ij\tau}^{\theta_\tau})) \tag{8}$$

Based on (2),(3) and (5) it is obtained the overall objective function, pondered by a factor (α_D) :

$$V_{Total}(c) = \sum_{j=1}^{n_j} \left\{ \alpha_\lambda \cdot \sum_{\tau=1}^{n_\lambda} \left(\frac{c_{ij}^{\lambda_\tau} - c_{ij(worst)}^{\lambda_\tau}}{c_{ij(best)}^{\lambda_\tau} - c_{ij(worst)}^{\lambda_\tau}} \right) + \alpha_\omega \cdot \sum_{\tau=1}^{n_\omega} \left(\frac{c_{ij}^{\omega_\tau} - c_{ij(worst)}^{\omega_\tau}}{c_{ij(best)}^{\omega_\tau} - c_{ij(worst)}^{\omega_\tau}} \right) + \alpha_\theta \cdot \sum_{\tau=1}^{n_\theta} \left(\frac{c_{ij}^{\theta_\tau} - c_{ij(worst)}^{\theta_\tau}}{c_{ij(best)}^{\theta_\tau} - c_{ij(worst)}^{\theta_\tau}} \right) \right\} \tag{9}$$

The main function cost, is then subject to a group of constraints, related to the sustainability's vector/dimension, i.e.:

$$r_1 : \sum_{j=1}^{n_j} (v_{ij7} (c_{ij7}^{\lambda_7})) \geq \eta_{minimum \text{ available funds}} \tag{10}$$

$$r_2 : \sum_{j=1}^{n_j} (v_{ij6} (c_{ij6}^{\lambda_6})) \leq \eta_{maximum \text{ operation costs}} \tag{11}$$

$$r_3 : \sum_{j=1}^{n_j} (v_{ij6} (c_{ij6}^{\alpha_6})) \leq \eta_{maximum \text{ deadline}} \tag{12}$$

Given the problem's characteristics, most of all, related with its combinatorial nature, it was used NSGAI's optimization method to solve it, with its individual chromosome presented on Fig. 2.

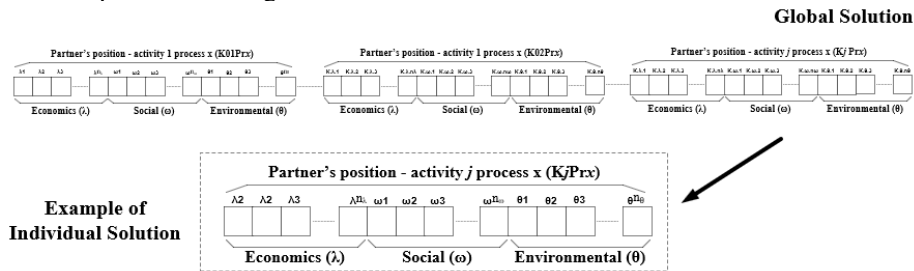


Fig. 2. NSGAI's individual framework.

For the NSGAI's chromosome, it was used real codification, given the nature of each one of decision variable used.

4 Results and Discussion

In order to evaluate the robustness of the model involved here, it was used a real situation, consisted of the development of an electric vehicle on behalf of a Collaborative Network (CN) established for that purpose.

The main goal was the develop an electric vehicle, to have one of the highest autonomy levels from the market, given its category.

This was done, by optimizing several components of the car (e.g., vehicle’s regenerative braking system, battery management system (BMS), aerodynamics, among other innovations). The CN has a total number of 27 Partners, and the framework, used to manage the innovation on CN established here, is based on the work from [7].

On Fig. 3, it is presented part of the table with the different skills and partners involved on this project, as well as part of the correspondent CN.

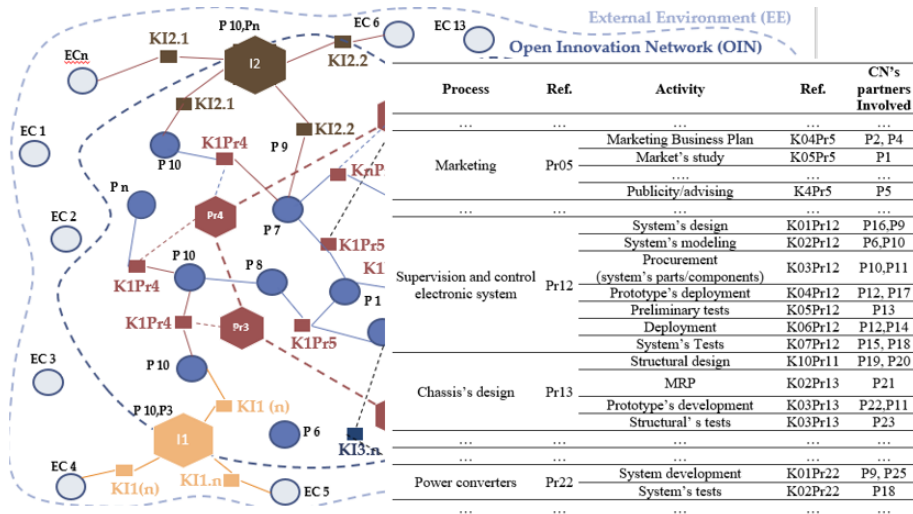


Fig. 3. Part of the CN developed including some of the partners and activities involved

Through the same figure, we can see part of the network created, as well as a table with some of the processes involved. The purpose is to share competencies and resources among the different partners (organizations) involved, to develop a new and innovative product, to better match the client requirements, aiming at the same time, to increase the credibility of the project, attracting therefore other investors that might be interested to fund the project.

Due to the diversity of processes and activities involved on this project, as well as the purpose of this work, it was selected only one process, where it is intended to add new partners on it. Therefore, on Table 3, it is presented the process Pr12, the activities related to it, and its needs in terms of new partners' positions to be fulfilled.

Table 3. Partner's positions to be fulfilled regarding process Pr12

Process (Prn)	Activity KnPrn	Partner's position (s) needed			
		Current Partner (s)		Partner (s) to full fill	
		Ref.:	Organization type	Ref.:	Organization type
Pr12 Supervision and control electronic system	K01Pr12	P16	University (R&D Group)	P9	University (R&D Group)
	K02Pr12	P6	Company	P10	Company
	K03Pr12	-	-	P10	n.d.
		-	-	P11	n.d.
	K04Pr12	-	-	P12	Company
	K05Pr12	-	-	P17	Company
	K06Pr12	-	-	P12	Company
		-	Company	P14	University (R&D Group)
K07Pr12	-	Company	P15	Company	
	P18		-		

n.d. - indifferent/not defined

Through Table 3, it can be seen that some of the positions to be filled, has some specific requirements regarding the type of organization to be included. For instance, while for the positions P10 and P11, the type of organization to be added is indifferent, for the position P14, it is required that the organization to be add should be an University (R&D group).

As it mentioned before and based on the model's architecture (Fig.1), it was pre-selected from 642 available partners (on total), 198 possible candidates, to be further classified according to multicriteria table, presented on Table 1.

After each candidate c_{ij} being scored on behalf of the three dimensions of sustainability, the correspondent individual solution was then structured according to the NSGAI's individual framework (Fig. 2) and then aggregated, in order to add the maximum value for the process Pr12, based on the three sustainable dimensions discussed before and according to the same framework presented on Fig.2.

NSGAI approach was then coded into Matlab® software, and runed in a CPU Intel i7, 3.2 GHz, in order to optimize the aggregated value function, presented before.

For the NSGAI's parameters, it was considered the following options/values:

- Selection method: roulette
- Mutation method: normal random
- Mutation rate [%]: 12 %
- Initial population: 200 individuals randomly generated
- Elitism: 12 individuals
- Crossover technique: double point
- Crossover rate [%]: 45 %
- Stop criteria: 142 generations

Some of these parameters, (including crossover and mutation rates and stop criteria), were previously tuned and obtained from previous tests.

On Figure 6, it is presented the correspondent Pareto surface.

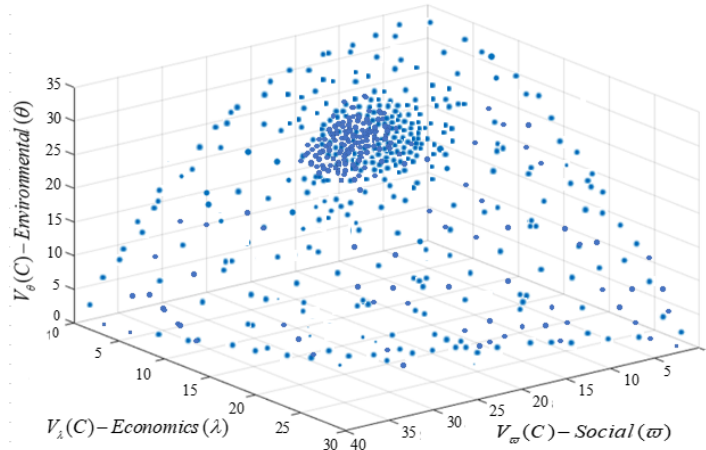


Fig. 6. Pareto Surface, obtained regarding a set of suitable solutions, classified according to the 3 Sustainability dimensions and their relative importance values (respectively for $\alpha_\lambda = 0,64$, $\alpha_\omega = 0,22$, $\alpha_\theta = 0,14$)

Through the Pareto Surface presented on Fig.4, it can be seen that each point (or node) represents a global solution, consisted in a group of individual solutions c_{ij} (partner's candidates) regarding each activity j , associated to process Pr12 (K_j Pr12).

Through the same figure, it's even possible the trade-offs between the different sustainability's dimensions.

Based on the Pareto's surface, presented on Fig.4, and by selecting one of the nodes from the region with more crowding space, it's possible select a suitable solution that allows to promote a high value for the process Pr12 regarding the dimensions of sustainability referred before. One of these nodes is presented on Table 4.

Table 5. Set of solutions achieved, considering $\alpha_\lambda = 0,64$, $\alpha_\omega = 0,22$ and $\alpha_\theta = 0,14$

Cand.	Suitable for position	Organization type	Average Deadline (months)	Operation Costs (k€)	Available funds (k€)	Partner's candidate				Assigned activity (es)	
						$V_\lambda^A(C^A)$	$V_\omega^{\omega}(C^{\omega})$	$V_\theta^\theta(C^\theta)$	$V_T^T(C)$	Ref.:	Description
C31	P9	University (R&D Group)	3,0	290	3					K01Pr12	System's design
C52	P10	Company	2,8	1952,8	2000,8					K02Pr12 K03Pr12	System's modeling
C33	P11	Company	4,0	385	400					K03Pr12	Procurement (system's parts/components)
C54	P12	Company	3,7	214	300					K04Pr12	Prototype's deployment
C25	P17	Company	3,1	11253	13000					K05Pr12	Preliminary tests
C16	P14	University (R&D Group)	4,0	325	4000					K06Pr12	Deployment
C37	P15	Company	6,0	658	856,23					K07Pr12	System's Tests
TOTAL			26,6	15077,8	17257,03	19,4	17,5	15,8	52,7		

Therefore, if the CN's board of management chooses this solution, presented on Table 5, he can expect to have for the activities regarding the process Pr12, an increase of 26,6 months, 15077800 € and 17257030 €, respectively regarded to the total values of average deadline, operation costs and available funds.

5 Conclusions of the Work

In this work, we've put forth a decision-support technique to choose acceptable partners for a Collaborative Network (CN) on behalf of the three sustainability dimensions, namely economic, social, and environmental.

With regard to the CN's pre-requirements, this method uses a pre-selection stage in which a pool of potential candidates is pre-selected from the market. The decision space, whose global solutions are produced by a set of individual solutions regarding each type of activity, is then determined based on a set of criteria developed on behalf of the three dimensions and by applying MAVT.

In order to optimize the value of each global solution, which is made up of a number of individual candidates, NSGA II was also used.

Each candidate is evaluated in light of a partner's open position as well as an activity connected to a certain procedure.

In addition to classifying each global solution according to the three sustainability dimensions that have been taken into consideration, it is also possible to determine which aspect of sustainability each specific solution scores the highest on and, consequently, which one is best suited to meet a given criterion. In order to tailor the solutions to the CN's objectives, the priorities of the relative importance, given to each of the three sustainability dimensions, can also be altered. For example, approaches like AHP.

The approach created here also enables the selection of partners with the next best score in order to handle potential eventualities that may happen with the candidates chosen to integrate the partnership (such as the unavailability of the selected partner after discussions take place).

The inclusion of evolutionary algorithms, such NSGA II, also makes it possible to have more workable alternatives available, which makes it possible to deal with unforeseen circumstances (like the resignation of some "chosen" candidates to fill the partner's position, for example).

Through the activities/processes taken into consideration here, mainly through its criteria, and its associated attributes as well, the approach proposed here can also be scaled up, to better answer the manager's board needs.

As a future lines of research, and in order to fulfill the needs of the current industry, the model developed here can be enriched with additional attributes, with some of them related to the social networks theory, and whose relevance, was previously discussed on literature review.

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