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Abstract. Collaborative Business Ecosystems have been benefiting from the technological advancements, allowing better collaboration among organisations to provide more innovative products and services in an increasingly demanding world. This collaboration can be assessed through a set of performance indicators, which also induce a self-adjustment of the organisations' behaviour, improving their profile and that of the ecosystem as a whole. In fact, their behaviour is expected to evolve (like individuals) according to the way they are evaluated. As such, this study presents a simulation model, which, together with the performance assessment and influence mechanism, is an essential contribution to measuring and influencing collaboration, enabling better management decisions. The model is based on agents and system dynamics, featuring a business ecosystem populated by organisations categorised according to a different profile, and configured and calibrated according to actual collaboration data. The samples were collected from two established companies operating in the same business ecosystem in the information technologies industry. Preliminary results of this approach, based on some simulation scenarios, are presented and discussed.

Keywords: Collaborative Networks, Collaborative Business Ecosystem, Performance Indicators, Agent-Based Modelling, System Dynamics.

1 Introduction

Technological advances that promote a digital world have boosted business ecosystems, where organisations collaborate in the search for innovative solutions for an increasingly demanding society. Moore [1] first introduced the concept of Business Ecosystem as a metaphor inspired by ecological ecosystems. On the other hand, the scientific area of Collaborative Networks (CN) [2], encompassing a broader scope, also considers business ecosystems as a particular case of Virtual organisations Breeding Environments. As such, and to emphasise the collaborative aspect, the term Collaborative Business Ecosystem (CBE) has been adopted [3]. In order to study the dynamics of such systems, a simulation model was proposed in [4].

The purpose of the current simulation study is to assess the influence of the performance indicators adopted in a CBE, which are likely to induce a self-adjustment of organisations, improving their profile and that of the ecosystem as a whole. A number of mechanisms to evaluate the performance of individual organisations are already established, of which the balanced scorecard (BSC) [5] is the best well-known. However, to assess collaboration and the associated benefits, only limited contributions can be found in the literature. As an example, [6] proposes a set of performance indicators for CNs based on collaboration benefits and a model to measure social capital in CNs providing indicators for assets and relationship analysis [7] inspired on Social Network Analysis (SNA) [8]. Another example, [9], suggests a conceptual model for value systems in CNs and proposes a method for assessing the alignment of the value systems of their members [10]. The research area of Supply Chain Collaboration (SCC) highlights the importance of collaboration in traditional supply chains and propose several metrics and methods [11], [12] and [13]. Nevertheless, the study of adequate performance indicators to be used in a business ecosystem remains a challenge. In this context, this work aims to contribute to the identification of suitable performance indicators to assess collaboration in a CBE, and more specifically to analyse the influence of such indicators in the ecosystem and its individual members.

The remaining sections of this paper are organised as follows: section 2 briefly positions this study in the context of innovation for life improvement; section 3 describes the proposed simulation model of the CBE, fundaments the choice and presents the performance indicators to assess the model, and explains the influence mechanism; section 4 presents the experimental evaluation of the simulation model using collected data from two organisations in the information technologies (IT) industry and discusses the results achieved; the last section summarises the contributions and identifies ongoing research and future work.

2 Relationship to Innovation in Life Improvement

Today's demanding and competitive market is very challenging for organisations in all sectors, including the field of information technologies. Participation in business ecosystems can help organisations to face such challenges. Companies must take advantage of the knowledge and shared assets owned by the business ecosystem where they operate, collaborating to make use of all available tools and concepts to provide innovative solutions in response to rapid market changes. The notion of a CBE re-enforces the idea of "community", contributing to the survival and improvement of all its members. When properly managed to promote sustainability, a CBE can in fact, contribute to life improvement of local societies.

The simulation model proposed in this work uses data collected from two organisations operating in the same business ecosystem. They produce solutions that help in the digital transformation of the internal processes of the companies, significantly reducing the need for paper, as well as solutions that contribute to data privacy and security, avoiding vulnerabilities that are easy targets for hackers. As such, the simulation model, together with the performance assessment and influence

mechanism, is an essential contribution to measuring and influencing collaboration, which could lead to better management decisions and thus an improvement of the involved organisations and the CBE as a whole.

3 A Model of a CBE for Performance Measure and Influence

Assessing the performance of a CBE is not an easy task due to the difficulty of gathering collaborative data from the organisations of the ecosystem. Simulation appears in this context as a way to overcome such difficulty. As such, for this research, a case study based simulation model which is tuned using information from two case companies. An analogous research methodology was also applied to supply chain collaboration [14]. As such, the performance indicators, the PAAM (Performance Assessment and Adjustment Model) and the influence mechanism proposed in [4] and [15], briefly described in the following sub-sections, are used to set up and assess the simulation model of the CBE presented in this simulation study.

3.1 Performance Indicators

The adopted performance indicators used to assess the collaboration of the organisations in a CBE are mainly based on measures borrowed from the area of social network analysis. The application of that area of research to inter-organisational contexts has seen an explosion of interest in the past recent years [16]. The network perspective, which is related to the structure of ties among organisations and the tie strength, has a significant influence on its behaviour and performance [16]. Coleman [17] identifies social capital in the relations among persons, which, as in physical and human capital, facilitates productive activity. In particular, the author highlights the importance of what he calls closure of social networks, a form of social capital, "*the trustworthiness of social structures that allows the proliferation of obligations and expectations*", facilitating collective sanctions and promoting reputation [17]. On the other hand, Burt [18] states that network density is a form of network closure since contacts in a dense network (i.e., more connections) are in close communication, increasing the readiness to enforce sanctions if norms are violated. Burt [18] also describes social capital as network structures, a metaphor in which social structure is a kind of capital that can create for certain individuals or groups a competitive advantage. However, the argument is that "*social capital is a function of brokerage structural holes*". The holes in the social structure of the market are weaker connections between groups, which create a competitive advantage for people whose relationships span the holes, giving them access to more information and control of communication because they reach more people indirectly [18]. Network betweenness proposed by Freeman in [19] and [20] measures the extent to which a node brokers indirect connections between all other nodes in a network.

Despite the existence of a large number of theories on inter-organisational networks in literature, most views argue that networks provide resources and capabilities from outside the organisations [16]. Based on a comprehensive study of the existing theories, an organising framework for inter-organisational research is

presented in [16], identifying four mechanisms that underlie and distinguish networks: “as resource access”, “as a source of trust”, “as a tool for power and control”, and “as a signalling mechanism”. The framework also organises the mechanisms by three levels of analysis: the “dyadic” (nature of the ties between two organisations), “ego” (the organisation) and the “whole network”. In short, findings at the dyadic level suggests: strong ties between two organisations increase trust between them and generate future ties, hight trust lowers transaction costs and increases benefits, and the most requested partner is argued to be the one with the most power [16]. At the ego level, different groups of findings can be found: hight degree centrality of organisations is positively related to their performance, structural holes and closure generate social capital, and network status explains organisational performance [16]. Finally, at the whole network level, the predominant research is focused on the characteristics of the entire inter-organisational network, such as density, centrality, clicks (clusters of connected organisations) [21] and small-worlds (clusters of locally dense clicks connected by a few bridging ties) [22]. Findings at the network level are extensive to discuss here, despite there is very little work about business networks [21]. However, there is evidence of the enhancement of the organisations’ innovativeness in small-worlds networks [16].

Following the main lines of research and findings described above, the proposed performance indicators were designed to assess a CBE considering a business ecosystem as a network of organisations (the nodes), connected by relationships (the ties) that mean the market opportunities they share collaborating, called collaboration opportunities. The metrics consider the weighted (tie strength) of the connections, due to their evidence in terms of performance and trust between organisations [16], [17] and [18].

The referred performance indicators are based on measures of density and weighted centrality in social networks analysis [19], [20], [23] and [24], and are calculated for the organisations as individuals and for the CBE as a whole. Table 1, Table 2 and Table 3 describe these indicators, respectively, the Contribution Indicator (CI), the Prestige Indicator (PI), and the Innovation Indicator (II). CI measures the value created by collaboration in the CBE, PI the influence/prominence of the organisations in the CBE, and II the innovation potential of the CBE. These indicators are based on measures of weighted centrality in social networks analysis [19], [20], [23] and [24], are calculated both for the organisations as individuals and for the CBE as a whole.

Table 1. Description of the Contribution Indicator.

Contribution Indicator (CI)	
Metric	**Description**
$O_1,\ldots,O_n$	Organisations in the CBE
#O	Number of organisations in the CBE
$\#CoOp_i$ in	No. of collaboration opportunities the organisation O_i gained from the CBE
$\#CoOp_i$ out	No. of collaboration opportunities the organisation O_i brought in the CBE
$\sum_i \#CoOp_i$	Total no. of collaboration opportunities created in the CBE
$C_D(O_i)$ in/out	Weighted indegree/outdegree centrality (C_D) of the organisation O_i in the CBE, which stands for the sum of direct connections in/out of O_i to the n organisations O_j, with weight $\#CoOp_{ij}$
$C_D(O^*)$ in/out	Maximum indegree/outdegree centrality of O_i
Contribution Indicator of an Organisation (CI_i)	
$CI_i in = \frac{C_D(O_i)in}{C_D(O^*)in} = \frac{\sum_j O_{ij}\#CoOp_{ij}in}{\max \sum_j O_{ij}\#CoOp_{ij}in}$	Assesses the contribution of organisation Oi in terms of accepted collaboration opportunities (more related to the popularity of organisations)
$CI_i out = \frac{C_D(O_i)out}{C_D(O^*)out} = \frac{\sum_j O_{ij}\#CoOp_{ij}out}{\max \sum_j O_{ij}\#CoOp_{ij}out}$	Assesses the contribution of organisation O_i in terms of created collaboration opportunities (more related to the activity of
Note: The values of CI_i are normalised between [0..1] in relation to the maximum degree centrality for the current network.	
Contribution Indicator of the CBE (CI_{CBE})	
$CI_{CBE}t = \frac{\sum_i \#CoOp_i}{\#O}$	Ratio of the total number of collaboration opportunities created/accepted in the CBE by the total number of organisations
$CI_{CBE}in = \frac{C_D(CBE)in}{max C_D(CBE)in} = \frac{\sum_i [C_D(O^*)in - C_D(O_i)in]}{C_D(O^*)in * (\#O - 1)}$	Assesses the degree to which the most popular organisation (in terms of accepted collaboration opportunities) exceeds the contribution of the others
$CI_{CBE}out = \frac{C_D(CBE)out}{max C_D(CBE)out} = \frac{\sum_i [C_D(O^*)out - C_D(O_i)out]}{C_D(O^*)out * (\#O - 1)}$	Assesses the degree to which the most active organisation (in terms of created collaboration opportunities) exceeds the contribution of the others
Note: The values of CI_{CBE} are normalised [0..1] in relation to the maximum sum of differences of degree centralities for the current network.	

Table 2. Description of the Prestige Indicator.

Prestige Indicator (PI)	
Metric	**Description**
$O_{1,}\ldots,O_n$	Organisations in the CBE
#O	Number of organisations in the CBE
$\#CoOp_i$	No. of collaboration opportunities the organisation O_i participated in the CBE
$\#CoOp_{kj}$	No. of collaboration opportunities between the organisation O_k and O_j in the CBE
$C_B(O_i)$	Weighted betweenness centrality (C_B) of the organisation O_i in the CBE, which stands for the sum of overall partial betweenness of O_i relative to all pairs O_{kj}, assuming that connections between O_k and O_j have weight of $\#CoOp_{kj}$
$C_B(O^*)$	Maximum betweenness centrality of O_i
Prestige Indicator of an organization (PI_i)	
$PI_i = \frac{C_B(O_i)}{C_B(O^*)} = \frac{\sum_k \sum_j O_{kj}(O_i)}{\max \sum_k \sum_j O_{kj}(O_i)}$	Assesses the prominence/influence of organisation O_i in terms of collaboration opportunities
Note: The value of PIi is normalised between [0..1] in relation to the maximum betweenness centrality for the current network.	
Prestige Indicator of the CBE (PI_{CBE})	
$PI_{CBE} = \frac{C_B(CBE)}{maxC_B(CBE)} = \frac{\sum_i [C_B(O^*) - C_B(O_i)]}{C_B(O^*) * (\#O - 1)}$	Assesses the degree to which the most prominent/influent organisation exceeds the contribution of the others
Note: The value of PI_{CBE} is normalised between [0..1] in relation to the maximum possible sum of differences of betweenness centralities for the current network.	

Table 3. Description of the Innovation Indicator.

Innovation Indicator (II)	
Metric	**Description**
$O_{1,}\ldots,O_n$	Organizations in the CBE
#VO	Number of virtual organizations created in the CBE
$\#VO_i$	Number of VOs in which O_i participated
#PortPd	Total portfolio of products/services/patents of the CBE
$\#PortPd_i$	Portfolio of products/services/patents of the O_i
#NewPd	Total of new products/services/patents generated in the CBE
$\#NewPd_i$	Number of new products/services/patents generated by O_i
Innovation Indicator of an Organisation (II_i)	
$II_i = \frac{\#NewPd_i}{\#PortPd_i}$	Measures the ratio of the number of new products/services/patentes of the organisation O_i by the total portfolio created
Note: The values of II_i are normalised between [0..1] in relation to the sum of the values of the indicators of all	
Innovation Indicator of the CBE (II_{CBE})	
$II_{CBE} = \frac{\sum \#NewPd_i}{\sum \#PortPd_i} * r(\#VO, \#NewPd)$	Calculates the ratio of the innovation of all the organisations in the CBE, weighted by the correlation between the collaboration (participation in VOs) and the new products/services/patents created
Note: The value of II_{CBE} is normalised between [0..1].	

3.2 Simulation Model

The simulation model PAAM, illustrated in Fig. 1. , is built using AnyLogic tools [25]. The CBE is represented by an environment of agents, the organisations, whose behaviour is modelled using agent-based modelling (ABM), system dynamics (SD) and statecharts. The organisations collaborate by creating or accepting collaboration opportunities (CoOps) expressed by directed connections of weight w_{ij}, meaning the number of times the organisation i collaborated with the organisation j.

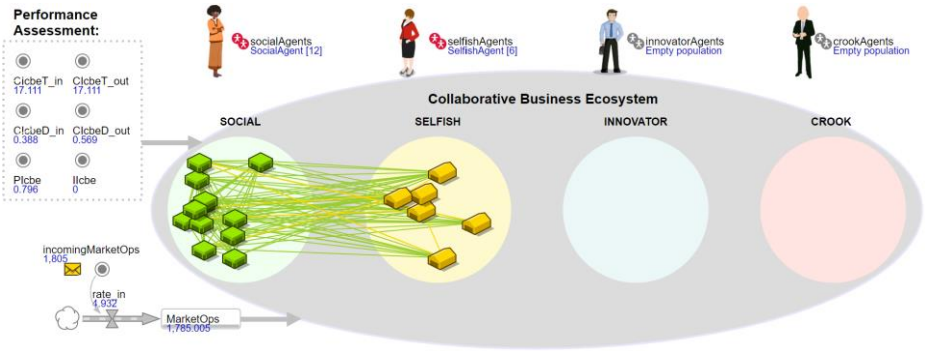

Fig. 1. PAAM simulation of a CBE using 12 social and 6 selfish agents.

The model supports a variety of organisations with different profiles, categorised into classes (Social, Selfish, Innovation and Crook), to better characterise the diversity of an actual business ecosystem. Each class, designated by Class of Responsiveness, is typified by the parameters described in Table 4, defining how organisations behave regarding collaboration in response to market opportunities.

Table 4. Parameters to characterise the classes of responsiveness in terms of collaboration.

Classes of Responsiveness	
Contact rate	Willingness to invite other organisations to collaborate
Accept rate	Readiness to accept invitations
New products rate	Tendency to accept opportunities related to innovation

It is expected that the performance evaluation method/indicators can influence the behaviour of organisations by causing them to self-adjust by enhancing their behaviour as a result of the metrics used. As such, if the indicators are properly chosen, this can result in an improvement of the ecosystem as a whole.

3.3 Influence Mechanism

The approach regarding the influence mechanism considered in this simulation study [15] is based on the importance (weight) given to each performance indicator. As such, the variation of the respective weights causes a redistribution of the percentage of resources allocated to each activity, by the organisations, trying to improve their performance according to the way they are evaluated. Thus, considering the resources allocated to three main activities: R&D, Consulting, and Inner tasks, the

corresponding influence of the indicators, and a given factor of influence (% of improvement), as illustrated in Table 5, the respective reallocation of resources can be calculated by the formula (1).

Table 5. Distribution of the influence of the weights of the indicators to the resources allocated to each activity.

Influence Mechanism	
Factor of Influence: FI (%)	
Activity	**Weights**
R&D	wII
Consulting	wCI, wPI
Inner tasks	-

$$Resources_{forActivity} = Resources_{forActivity_{base}} - \frac{FI}{3} + \frac{(wCI + wPI + wII) * FI}{wII + wCI + wPI} \quad (1)$$

4 Experimental Results of the Simulation Study

For the experimental results of this simulation study, several organisations operating in the same business ecosystem, in the IT industry, were contacted. From two of them who collaborate with some common partners, we were able to collect business and collaboration data regarding the year of 2019. Both organisations are established companies in the high-tech industry, having as technology vendors IBM and Outsystems, and operate in a business ecosystem that can be characterised in terms of entrepreneurship and strategic thinking as a mix of the "Orchestra" and "MOD Station" models [26].

Organisation1 is a system integrator with solutions focused on the management of non-structured contents like contracts, invoices, emails, forms among many others. The organisation integrates technologies from various vendors to build solutions for the corporate and government markets, has partnerships with Universities for R&D processes, and also has its own software products that in many projects act as the orchestrators of several technologies of its partners.

Organisation2 is a system integrator with solutions focused on cybersecurity and networking. The organisation integrates technologies from various vendors to build solutions for the corporate and government markets. Due to its high technical specialisation, it is often subcontracted by local big IT companies to provide consultancy and engineering services to their customers, or new suppliers suggest innovative solutions and areas of supply. Because the cybersecurity sector is evolving rapidly, the organisation has significant activity in managing the supplier ecosystem, being very dynamic in responding and inducing new ideas to market needs.

For each organisation, the collected data described in Table 6 and Table 7 were: (1) Number of persons working in research and development, consulting or inner tasks; (2) Number of market opportunities received and accepted indicating the minimal, maximal and typical duration expressed in days/person; (3) Number of collaboration opportunities created by inviting partners, the percentage of business invites sent and the percentage of acceptance by the recipients; (4) Number of collaboration

opportunities received from the partners and percentage of acceptance; (5) Total number of products/services produced and in how many of these there were innovation and collaboration.

Table 6. Sample data from Organisation1 collected in the year 2019.

Organisation1						
Resources (persons)	R&D		Consulting		Inner tasks	
	2		28		3	
Market Opportunities	Received	Accepted	Duration (days/person)			
	#	#	min	mode	max	
	27	15	30	60	2000	
Collaboration Opport.	Invites sent		Business units sent		Acceptance	
Sent	min	max	min	max	min	max
Partner1	1	2	0,8%	1,7%	50%	100%
Partner2	2	3	3,0%	4,5%	80%	100%
Partner3	1	2	0,4%	0,8%	50%	75%
Partner4	3	4	1,2%	1,7%	50%	75%
	Invites received		Acceptance			
Received	min	max	min		max	
Partner1	3	4	70%		80%	
Partner2	2	3	50%		60%	
Partner3	3	4	80%		90%	
Partner4	6	7	90%		100%	
Partner5	8	10	30%		50%	
Partner6	2	3	50%		70%	
Partner7	1	2	100%		100%	
Partner8	2	3	50%		50%	
Partner9	1	2	70%		100%	
Partner10	4	5	30%		50%	
Partner11	1	2	100%		100%	
Products/Services	Total portfolio		Innovative		In collaboration	
	16		10		6	

Table 7. Sample data from Organisation2 collected in the year 2019.

Organisation2						
Resources (persons)	R&D		Consulting		Inner tasks	
	0		14		2	
Market Opportunities	Received	Accepted	Duration (days/person)			
	#	#	min	mode	max	
	98	88	0	10	30	
Collaboration Opport.	Invites sent		Business units sent		Acceptance	
Sent	min	max	min	max	min	max
Partner4	0	1	0,0%	4,7%	0%	100%
Partner12	1	1	5,5%	5,5%	100%	100%
Partner13	1	3	5,5%	16,7%	100%	100%
Partner14	1	2	1,7%	3,4%	100%	100%
	Invites received		Acceptance			
Received	min	max	min		max	
Partner2	1	1	100%		100%	
Partner15	1	2	100%		100%	
Partner16	1	1	100%		100%	
Products/Services	Total portfolio		Innovative		In collaboration	
	80		10		3	

After analysing the collected data, a consolidated summary is displayed in Table 8. The contact rate is the ratio between the number of collaboration opportunities sent by the number of market opportunities accepted. The accept rate is the percentage of accepted collaboration opportunities concerning the number of invites received. It is also considered that the first organisation has a "social" profile because of the high contact and accept rate, and the second one a "selfish" profile because it accepts almost all invitations but has a low contact rate.

Table 8. Consolidated samples of data from Organisation1 and Organisation2.

	Organization1 (Social)			**Organization2 (Selfish)**		
Resources	**value**			**value**		
Total (persons)	33			16		
Total (days/person)	7260			3520		
R&D	6%			0%		
Consulting	85%			87%		
Inner Tasks	9%			13%		
Market Opportunities	**value**			**value**		
Accepted	15			88		
	min	**mode**	**max**	**min**	**mode**	**max**
Duration regular (days/person)	30	60	100	0	10	30
Duration sparse (days/person)	100		2000	60		200
Collaboration Opportunities	**min**	**mode**	**max**	**min**	**mode**	**max**
Invites sent	7		11	3		7
Contact rate	47%		73%	3%		8%
Business units sent	0,4%	0,8%	4,5%	0,0%	5,5%	16,7%
Invites received	33		45	3		4
Accept rate	30%	50%	100%	100%	100%	100%

The PAAM system was configured using the data of Table 8 to simulate the behaviour of the agents, as shown in Fig. 1. , populated with 12 social organisations and 6 selfish ones, to simulate a scenario that totals a similar number of agents as the actual CBE of the Organization1 and the Organization2. A different number of combinations can be set to simulate different scenarios. To simulate the contact rate, accept rate, and percentage of business sent, we used Bernoulli and triangular distributions [27], the last one parametrised with the corresponding min, mode and max values.

The simulation model represents a scenario of one year, bringing to the CBE 1500 market opportunities plus 20% of innovative opportunities using the Poisson distribution [28]. To the same scenario, we applied the influence mechanism considering Table 5 parametrised as shown in Table 9.

Table 9. The factor of influence and weights of the indicators considered for the scenario of simulation.

Influence Mechanism	
Factor of Influence: FI=10 %	
Activity	**Weights**
R&D	wII=1
Consulting	wCI=4, wPI=2
Inner tasks	-

The achieved results of the performance assessment before and after the influence mechanism are displayed in Table 10.

Table 10. Calculated values of the CI and PI for each organisation and for the CBE as a whole, before and after the influence mechanism.

Performance Assessement of the CBE				
Class Resp.	**O_i**	**CI_i in**	**CI_i out**	**PI_i**
Social	0	0,59	0,54	0,18
	1	0,48	0,70	0,06
	2	0,44	0,76	0,26
	3	0,37	0,76	0,11
	4	0,63	0,62	0,34
	5	0,63	1,00	1,00
	6	0,81	0,62	0,48
	7	0,48	0,57	0,42
	8	0,52	0,57	0,22
	9	0,30	0,65	0,00
	10	0,59	0,59	0,31
	11	0,59	0,70	0,29
Selfish	12	1,00	0,00	0,00
	13	0,78	0,03	0,00
	14	0,96	0,08	0,00
	15	0,74	0,03	0,00
	16	0,85	0,08	0,00
	17	0,63	0,03	0,00
		CI_{CBE} t = 17,1		
		CI_{CBE} in = 0,39		**PI_{CBE} = 0,80**
		CI_{CBE} out = 0,57		

Performance Assessement of the CBE				
Class Resp.	**O_i**	**CI_i in**	**CI_i out**	**PI_i**
Social	0	0,38	0,56	0,02
	1	0,41	0,71	0,19
	2	0,53	0,88	1,00
	3	0,41	0,74	0,64
	4	0,41	0,79	0,09
	5	0,53	1,00	0,87
	6	0,38	0,74	0,72
	7	0,38	0,76	0,17
	8	0,32	0,91	0,67
	9	0,18	0,59	0,09
	10	0,38	0,56	0,39
	11	0,26	0,71	0,02
Selfish	12	0,85	0,00	0,00
	13	0,68	0,09	0,00
	14	0,62	0,03	0,00
	15	1,00	0,09	0,19
	16	0,85	0,09	0,01
	17	0,68	0,03	0,01
		CI_{CBE} t = 17,5		
		CI_{CBE} in = 0,51		**PI_{CBE} = 0,72**
		CI_{CBE} out = 0,51		

For a better perception of the results of Table 10, Fig. **2.** , Fig. **3.** , Fig. 1 and Fig. 2 show a visual graph representation of the models of the CBE using the graphic tool Gephi [29], highlighted by colour and size (darker colours and larger sizes), the organisations with a higher contribution and more prestige.

Analysing the results of the Contribution Indicator, the values of CI_iout show that the organisations tried to increase collaboration by sending more invitations, although some have accepted fewer opportunities (CI_iin), perhaps because they did not have enough resources. As a result, the ratio of collaboration opportunities in the CBE (CI_{CBE}t) has improved somewhat. On the other hand, CI_{CBE}out shows a more uniform collaboration in the CBE, but CI_{CBE}in has worsened.

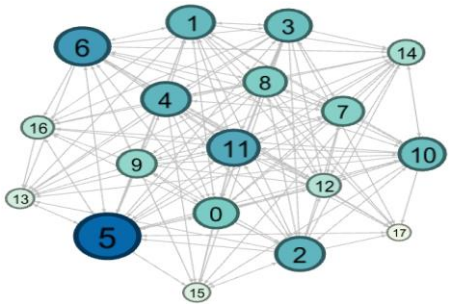

Fig. 2. Ranking of CI.

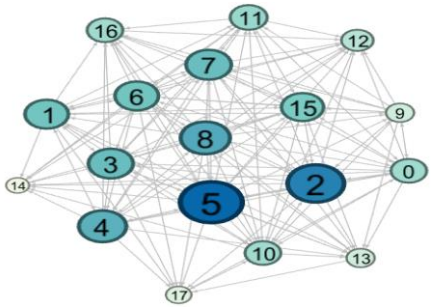

Fig. 3. Ranking of CI after influenced.

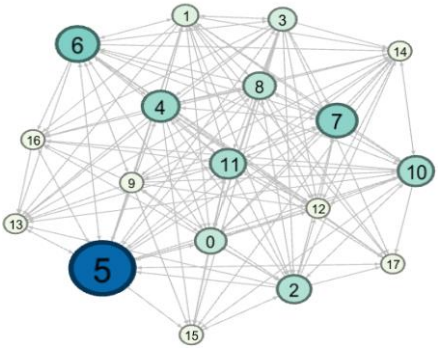

Fig. 1. Ranking of PI.

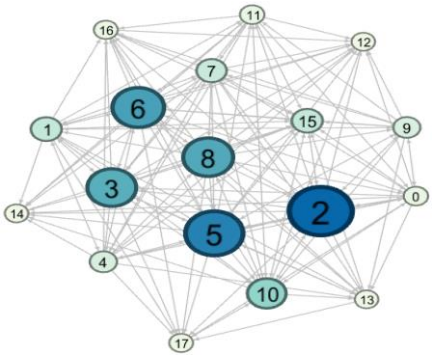

Fig. 2. Ranking of PI after influenced.

Finally, analysing the results of the Prestige Indicator, it can be seen that almost all the organisations increased their influence/prominence (PI_i), also improved PI_{CBE}, resulting in a more uniform ecosystem in terms of the prestige of its organisations.

5 Conclusions and Further Work

The results of the experimental simulation study show that it is possible to populate and calibrate the PAAM system using actual data of organisations operating in the

same business ecosystem. Then, it can be assessed by the adopted performance indicators and influenced by varying their significance (weights). Several scenarios can be set using a variable number or organisations of different profiles. As such, choosing the appropriate indicators, it can result in an improvement of the organisations and of the ecosystem as a whole. Such results can be used by managers to decide on the CBE governance.

The ongoing work aims to collect more collaboration data from organisations to improve the simulation model taken into account more characteristics of the business model, and also to enhance the influence mechanism by introducing more variables related to the motivation of organisations to evolve their collaboration behaviour.

The future work includes the calculation of the Innovation Indicator (II) and its correlation with collaboration.

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