Received: 20 Mar 2022 | Accepted: 23 May 2022 | Available online: 23 June 2022
DOI: http://dx.doi.org/10.18180/tecciencia.2022.32.7

TECCIENCIA

UNIVERSIDAD · ECCI

RESEARCH ARTICLE

Engineering

Network evolution in theory and as observed, the case of the Industrial Knowledge Bank of Latin America.

Evolución de las redes en la teoría y en la práctica, el caso del Banco Industrial del Conocimiento de América Latina.

Gesny Yadira Baquero Cruz [1] | **Greys M. Florez Torres** [2] | **Gerhard Hanappi** [1]

[1]Business Informatics Institute,Vienna University of Technology, Vienna, Austria.

[2]Harvard University, Extension School, Cambridge, United States.

Correspondence
Gesny Yadira Baquero Cruz
Email: e0353820@student.tuwien.ac.at

How to cite: Gesny Yadira Baquero Cruz & Gehard Hanappi., **Network evolution in theory and as observed, the case of the Industrial Knowledge Bank of Latin America.**, TECCIENCIA, Vol. 17, No. 32, 77-91, 2022
DOI:http://dx.doi.org/10.18180/tecciencia.2022.32.7

Abstract. This paper provides an evaluation of a theoretical approach of network theory that describes network evolution by comparing it to an observed evolution of an industrial cooperation network connecting different countries. The theoretical approach considered is the well-known preferential attachment mechanism leading to power-law distributions developed by Albert Barabási. The empirical phenomenon studied is the evolution of the Industrial Knowledge Bank (IKB) maintained by The United Nations Industrial Development Organization (UNIDO). By fitting a discrete power law to the empirical data collected during the 4 years of operation of the IKB project and testing the goodness-of-fit using the bootstrapping procedure, it is shown that the theoretical framework in its most elementary form is adequate to grasp the essential features of the observed case. The comparison also leads to an improved understanding of very influential social factors like language and geographical distance, thus can give valuable insight for the further theoretical advances in theoretical work on network evolution and its applications to Social, Industrial, and Economic Development.

Keywords: theoretical approach, network theory, network evolution, industrial cooperation network, preferential attachment, Industrial Knowledge Bank (IKB).

Resumen

Este artículo ofrece una evaluación de un enfoque teórico de la teoría de redes que describe la evolución de las mismas, comparándolo con la evolución observada de una red de cooperación industrial que conecta diferentes países. El enfoque teórico considerado es el conocido mecanismo de adhesión preferente que conduce a distribuciones de ley de potencia desarrollado por Albert Barabási. El fenómeno empírico estudiado es la evolución del Banco de Conocimientos Industriales (IKB) mantenido por la Organización de las Naciones Unidas para el Desarrollo Industrial (ONUDI). Mediante el ajuste de una ley de potencia discreta a los datos empíricos recogidos durante los 4 años de funcionamiento del proyecto IKB y la comprobación de la calidad del ajuste mediante el procedimiento de bootstrapping, se demuestra que el marco teórico en su forma más elemental es adecuado para captar las características esenciales del caso observado. La comparación también conduce a una mejor comprensión de factores sociales muy influyentes como el idioma y la distancia geográfica, por lo que puede ofrecer una valiosa perspectiva para los futuros avances en el trabajo teórico sobre la

evolución de las redes y sus aplicaciones al desarrollo social, industrial y económico.

Palabras clave: enfoque teórico, teoría de redes, evolución de redes, red de cooperación industrial, apego preferencial, Banco de Conocimiento Industrial (IKB).

1 | INTRODUCTION

The Industrial Knowledge Bank (IKB) of the United Nations Industrial Development Organization (UNIDO) is a platform created to mobilize human resources, knowledge and expertise in Latin American and Caribbean (LAC) countries [1]. The IKB is also a modern cooperation tool intended to aid in the exchange of knowledge and expertise on industrial and productive development among LAC countries. It is an innovative mechanism of South-South Cooperation [2] which was created in order to facilitate the transfer of industrial knowledge, promote development and improve production through the exchange of experts between LAC countries [1].

The database is useful to all institutions in the industrial and productive sectors of the LAC countries, public and private organizations, small and medium scale enterprises, universities, technological centres, and research centres. The main motivation behind this paper was the direct contribution to implementing, coordinating and managing technical cooperation between fifty-three pairs of countries in Latin America, Europe and Africa via the IKB [1].

Some examples of cooperation networks in Latin America and the Caribbean include: Red Iberoamericana de Indicadores de Ciencia y Tecnología [3]; Red de Popularización de Ciencia y Tecnología en América Latina y el Caribe [4]; The Caribbean Diaspora for Science, Technology & Innovation [5]; Red Europea de Información y Documentación sobre América Latina [6]; CLACSO's Research Promotion Area [7]; Observatorio Social para America Latina [8]; Inter-American Development Bank [2]; Plataforma para potenciar las Políticas de Seguridad Alimentaria y Nutricional en América Latina y el Caribe [9].

However, the following analysis is based on research that the [1] conducted over a five-year period (2009-2013) and that covers the sectors of mining, agronomic industry, trade capacity building , and energy and the environment. Network theory is broadly used to study many systems including network performance of computer architectures [10], air quality of cities [11], Bayesian Newtworks structures, and social networks [12]. The main objective of this paper is to apply the preferential attachment model to the analysis of the social network dynamics of the IKB. The contribution of this investigation consists in the application of a theoretical approach to a real-life cooperation network to test the theory's practical strengths and limits.

While there exist other papers on Social Network Analysis in Latin America, including one study of the scientific productivity in South American countries regarding the topic, this is the first study to apply the Scale-free Networks Theory and Preferential Attachment Model [13] to analyze the behavior of the [1] network in areas related to industrial development, and for which Technical Cooperation were carried out in real time.

2 | MATERIALS AND METHODS

The data used for this study were the Technical Cooperation carried out within the framework of the Industrial Knowledge Bank during its five years of operation in Latin America between 2009 and 2013 [1]. In this period a total number of 53 technical assistances between institutions in Latin America and cooperating entities in Europe and Africa were realized A.

The main actors participating in the construction of the IKB Network for Latin American Industries were public and private industrial organizations belonging to the industrial and productive sectors in the LAC region, and industrial and business institutions in Europe and Africa (Equatorial Guinea). All these organizations acted as knowledge donors A.

For this paper, this data was analyzed according to the preferential attachment model; "Preferential attachment is generally understood as a mechanism where newly arriving nodes have a tendency to connect with already well-connected nodes" [14] Moreover, "the term preferential attachment refers to the observation

that in networks that grow over time, the probability that an edge is added to a node with "d" neighbors is proportional to "d" This linear relationship lies at the heart of Barabási and Albert's scale-free network model and has been used in a vast number of subsequent work to model networks, both online and offline" [15].

"In other words, the network grows with each new node, and the new nodes are more likely to attach to those that already have edges. Thus, the preferential attachment mechanism means that the probability that an existing node acquires more edges is proportional to the number of edges it already has at that point in time" [16].

The concept of preferential attachment has slightly different interpretations depending on the type of networks considered. "In order to distinguish these different cases, we classify the networks available to us into seven categories, depending on the underlying entities and relationships represented by vertices and edges. Although some networks are genuinely undirected, such as a friendship network, many networks represent asymmetric relationships that allow us to distinguish active and passive nodes, depending on the role they play in the creation of edges", according to [15].

The social networks considered in the study are based on online social networking sites and therefore the social ties they reflect are online contacts. They consist of persons connected by social ties such as friendship [15]. Some social networks have positive and negative edges, representing positive and negative ties such as friendship and enmity or trust and distrust. In such cases, only the presence of a tie is of any interest. Some social networks are undirected, and others are directed. For directed social networks, a directed edge from person A to person B means that person A is either following or connected in a unilateral way with another person B [15].

3 | ANALYSIS OF THE MODEL

Observing the behavior of the Technical Cooperation subject of this analysis from the perspective of social network dynamics, this paper studies those dynamics in relation to the extensively analyzed and studied preferential attachment model [17].

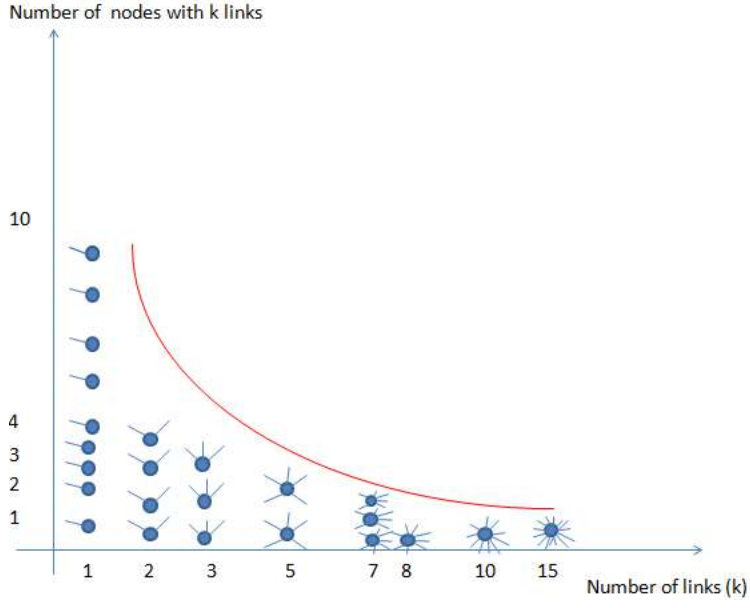

FIG. 1 Number of links (k)" vs "Number of nodes with k links" Distribution for IKB (2009-2015).

According to the preferential attachment model, a node's probability of attachment depends on the connections already present: the more connected the node is, the greater its probability of attachment to new

nodes, as expressed by the following Eq. (1)

$$\Pi_i = \frac{mk_i}{\sum_j k_j} \tag{1}$$

where Π_i is the probability of attachment of the node i, k_i is the connectivity of the node, and m are the links that connect two nodes, with each link representing a cooperation. According to [17] the power law for preferential attachment follows the Eq. (2)

$$P(k) = \frac{2m^2}{k^3}. \tag{2}$$

After t timesteps the Barabási-Albert model generates a network with $N = t + m_0$ nodes and $m_0 + mt$ links. In [14] shows that an a general network has a power-law degree distribution with degree exponent $\gamma = 3$. Beginning the analysis with a simple "number of links (k)" vs "Number of nodes with k links" graph can be appreciated in the scale-free network the nodes are not equal. Some nodes have a much higher connection level than others. Fig. 1 suggests plausibility of a power law distribution.

4 | RESULTS

We used R [18] with displ [19] to perform a fitting discreate power law approximation Fig. 2. The computations result on a threshold estimate of $x_{min} = 3$ and scaling parameter $\alpha = 3.057596$, which matches the power-law degree distribution with degree exponent 3 proposed by the theorical Barabási-Albert model [14].

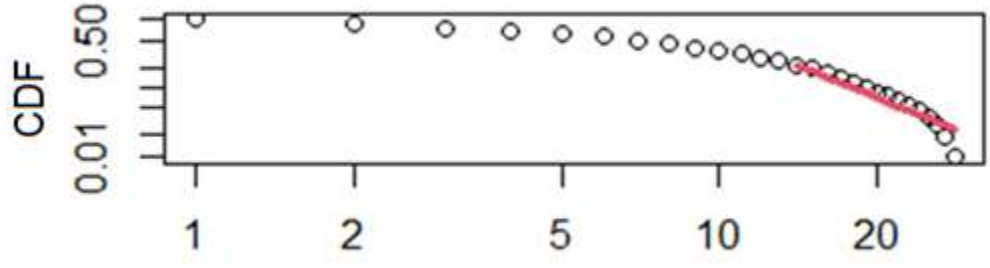

FIG. 2 Data CDF (Cumulative Distribution function) of links across nodes, which in context refers to cooperation between countries. The red line represents the power law of best fit.

Furthermore, by performing goodness-of-fit test, via a bootstrapping procedure Fig. 3 [20], a p-value of 0.81 is obtained, which give us an ~ 80% confidence on the adjustment of the networking evolution of UNIDO to the preferential attachment mechanism leading to power-law distributions developed by Albert Barabási.

Fundamentally, network theory is an appropriate and quantitatively orientable tool capable of producing interesting results. We applied the theory of preferential attachment to the IKB network case study and present another way of visualizing all the results. Fig. 4 shows the countries that participated in the Technical Cooperations.

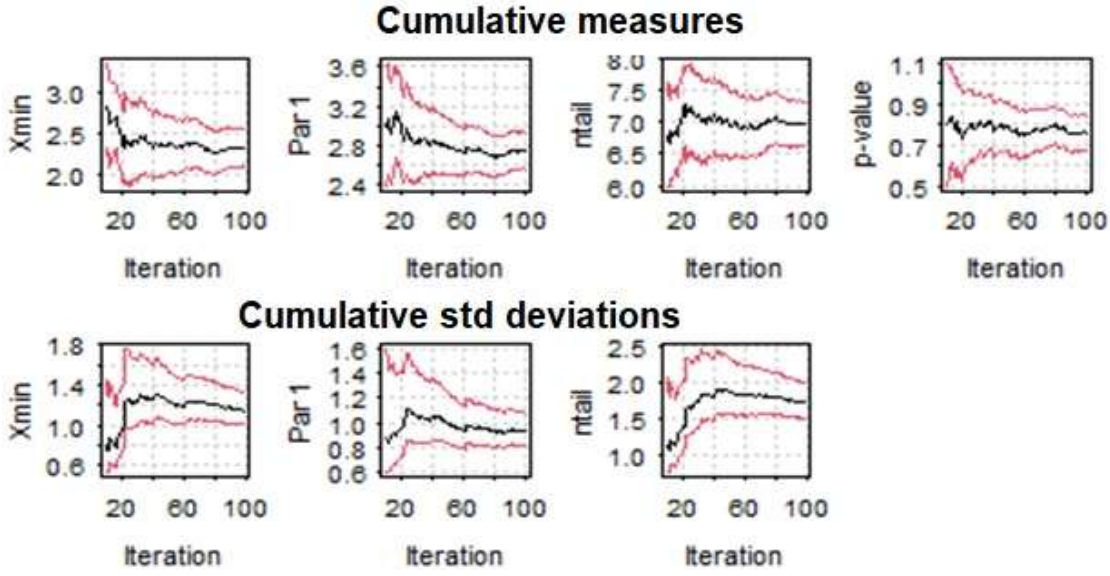

FIG. 3 Results from the standard bootstrap procedure (for the power law model) using number of nodes with k links data. The top row shows the mean estimate of parameters x_{min}, α and $n$tail. The bottom row shows the estimate of standard deviation for each parameter.

It can be noted that Argentina was the country with the most Technical Cooperations, followed by Ecuador, Paraguay, Colombia, Peru, and Spain. Interestingly, the countries (nodes) with more connections are all speakers of the same official language (Spanish), which suggest language sharing plays a significant role in the preferential expansion of the cooperation network.

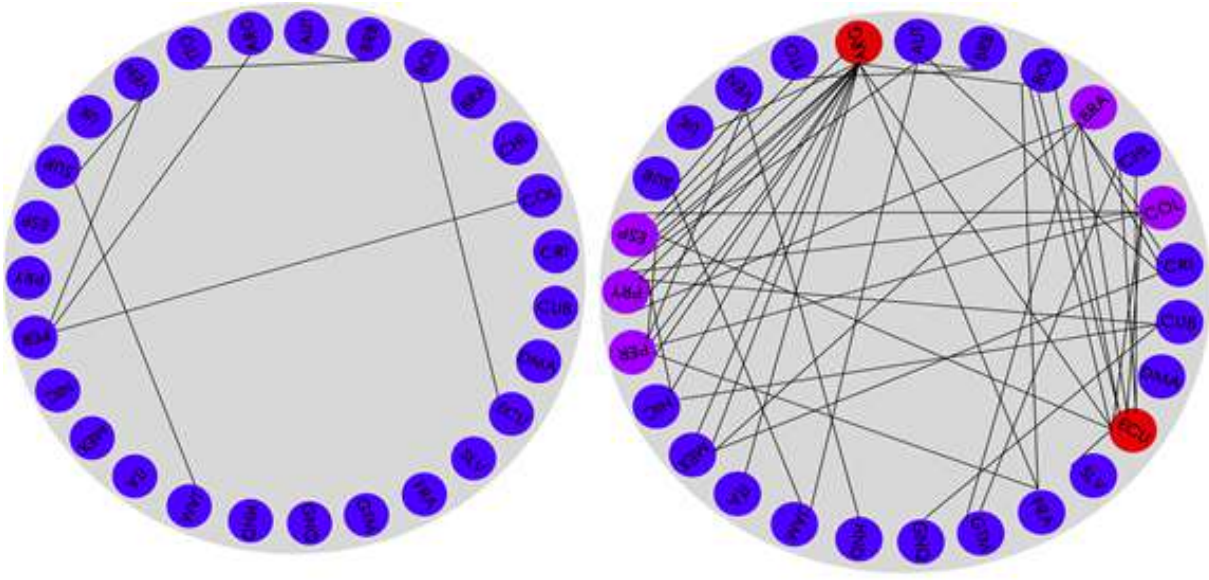

FIG. 4 Graphic representation of the network during the evaluated period, 2009 (left) and 2013 (right). The countries presenting higher, middle and low technical cooperations are represented by the red, purple and blue dots, respectively.

Based on the results and considering Barabasi's scale-free networks model, the most connected nodes are called centres, which in our case are Argentina, Ecuador, Paraguay, Colombia, Peru and Spain.

Finally, Fig. 5 below represents the cooperation network in the final year of the study. The graphic was

created using the programming language R due to its efficiency with big data clusters and ease of use in data processing and the creation of graphics involving plenty of information.

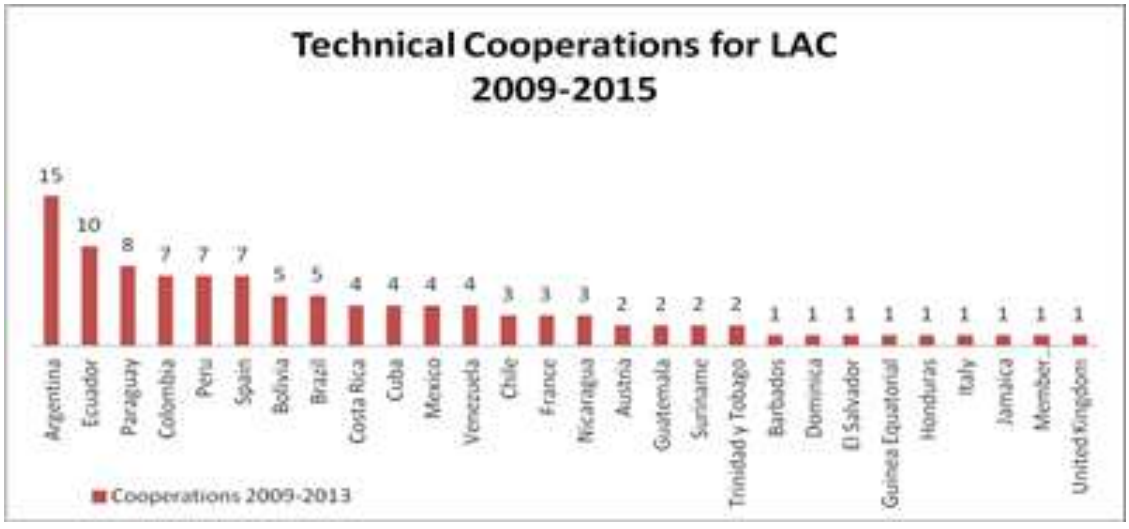

FIG. 5 Participation of countries TC - IKB (2009-2013). The index values reflect the participation of countries in descending order according to the frequency with which they took part in the IKB's knowledge transfer activities (2009-2013).

Table 1 shows the countries in increasing order according to their level of participation in the Industrial Knowledge Bank in Latin America and the Caribbean.

TABLE 1 Participation of countries in increasing order by level of participation.

Number of cooperations k	Number of countries with k cooperations	Countries
1	9	Barbados, Dominica, El Salvador, Equatorial Guinea, Honduras, Italy, Jamaica, Member Caribbean States United Kingdom.
2	4	Austria, Guatemala, Suriname, Trinidad and Tobago.
3	3	Chile, France, Nicaragua.
4	4	Costa Rica, Cuba, Mexico, Venezuela.
5	2	Bolivia, Brazil.
7	3	Colombia, Peru, Spain.
8	1	Paraguay.
10	1	Ecuador.
15	1	Argentina.

It can be noticed that stronger nodes (nodes with a higher connection degree) are mostly located in a same geographic area. Since the cooperation were performed in person (physical displacement of experts to the receiver country was required in order to perform the cooperation) it can be inferred that travel distance was another important factor at the time of choosing preferred connections.

5 | DISCUSSIONS AND CONCLUSIONS

As can be appreciated in the scale-free network, the nodes are not identical. Some nodes have a much higher connection level than others Fig. 6. In this case study, the most connected nodes, or "Hubs" [21], represent countries that cooperated as knowledge donors and receivers between 7 and 15 times (Argentina, Ecuador,

Paraguay, Colombia, Peru and Spain). The biggest Hub in this case is Argentina. The medium nodes are Bolivia, Brazil, Costa Rica, Cuba, Mexico, Venezuela, Chile, France, and Nicaragua. The small nodes are Austria, Guatemala, Suriname and Trinidad and Tobago. Finally, the extremely small nodes are Barbados, Dominica, El Salvador, Equatorial Guinea, Honduras, Italy, Jamaica, Member Caribbean States, and the United Kingdom.

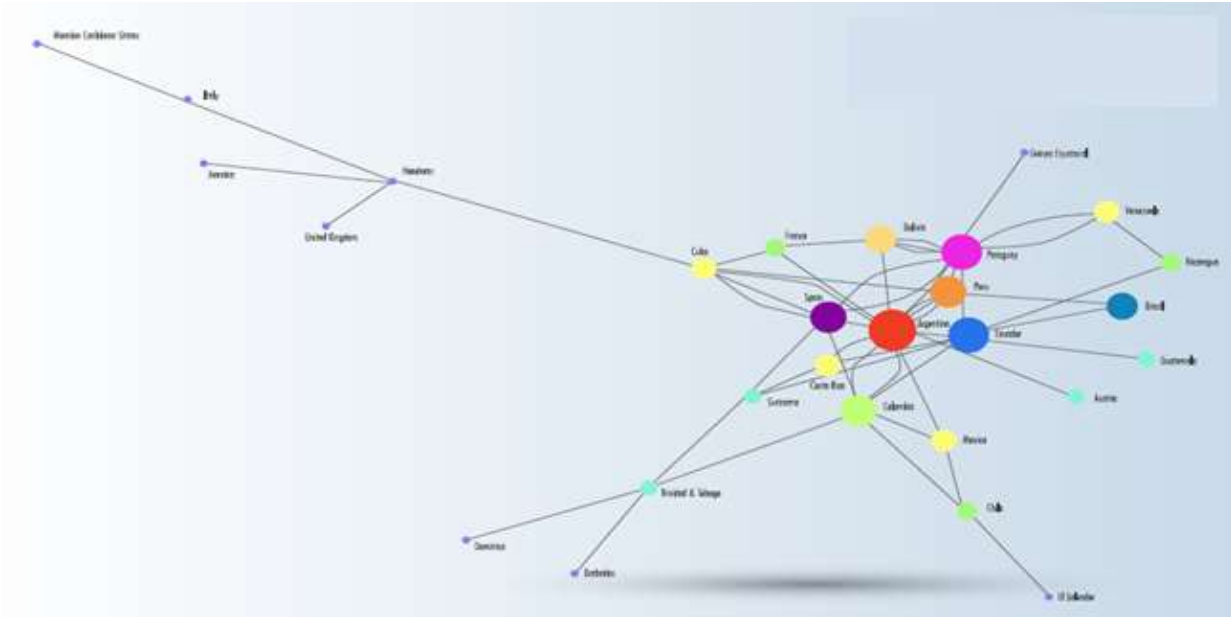

FIG. 6 Result of Evolution of a Knowledge Network for LAC created with R.

The connectivity and the functionality of the network highly depend on the existence of the Hubs. The other nodes are smaller and relate to other even smaller ones, which allow further interconnection and strengthen the functioning of the IKB network. Furthermore, testing the theory of preferential attachment led to the following conclusions:

- The theory of preferential attachment [22] explains that the power law should be strictly equal to 3. The observed IKB network data suggest a very close adjustment to the theorical model, with a best fit power law of 3.05. Furthermore, there is not enough evidence to reject the hypothesis that the date follows the preferential attachment model.
- According to the theory of preferential attachment [13], connection probability depends on the number of connections that each country already has. In the IKB network, Argentina, Paraguay, and Peru substantiated the principle that where there is already high connectivity there is a high probability of new connections.

Finally, we classified the represented countries' participation in the Technical Cooperations into high, medium, low and very low levels. High level countries: Argentina, Ecuador, Paraguay, Colombia, Peru and Spain. Medium level countries: Bolivia, Brazil, Costa Rica, Cuba, Mexico, Venezuela, Chile, France and Nicaragua. Low level countries: Austria, Guatemala, Suriname and Trinidad and Tobago. Very low-level countries (each one only participated once): Barbados, Dominica, El Salvador, Equatorial Guinea, Honduras, Italy, Jamaica, Caribbean Member States and the United Kingdom. This classification unveiled two interesting patterns: First, all Hubs are Spanish speaker countries, and second, most of the cooperations were concentrated in a same geographical area. These two patterns suggest a relevant influence of language and geographical distance in the "preference" factor of the network growth, that can be of further interest in future field networking experiences.

References

[1] D. Masera, "Industrial knowledge bank." Available at: https://www.unido.org/who-we-are-unido-worldwide-latin-america-and-caribbean-selected-projects/industrial-knowledge-bank, consulted on September 17 Jul. 2020.

[2] J. Zhao, "South-south and triangular industrial cooperation." Available at: https://www.unido.org/our-focus-cross-cutting-services/south-south-and-triangular-industrial-cooperation, consulted on September 17 Jul. 2020.

[3] RICYT, "Red de indicadores de ciencia y tecnología interamericana e iberoamericana." Available at: https://www.unido.org/our-focus-cross-cutting-services/south-south-and-triangular-industrial-cooperation, consulted on September 17 Jul. 2020.

[4] direccion, "Red de popularización de la ciencia y la tecnología en américa latina y el caribe (redpop)." Available at: https://redpop.lat/o-que-e-a-redpop, consulted on September 17 Jul. 2020.

[5] CADSTI, "Caribbean diaspora for science, technology innovation (uk)." Available at: https://cadsti.org.uk/, consulted on September 17 Jul. 2020.

[6] R. Redial, "Red europea de información y documentación sobre américa latina." Available at: https://rediceisal.hypotheses.org/, consulted on September 17 Jul. 2020.

[7] CLACSO, "Consejo latinoamericano de ciencias sociales." Available at: https://www.clacso.org/, consulted on September 17 Jul. 2020.

[8] OSAL, "Observatorio social de américa latina." Available at: https://www.ecured.cu/, consulted on September 17 Jul. 2020.

[9] FAO, "The food and agriculture organization of the united nations." Available at: https://www.fao.org/home/en, consulted on September 17 Jul. 2020.

[10] C. A. Martínez, D. A. L. Sarmiento, J. J. R. Ochoa, and R. D. G. Tovar, "Performance assessment of diffserv and intserv services in qos on an academic network using ns2," *Tecciencia*, vol. 7, no. 14, pp. 65–75, 2013. **DOI:** 10.18180/tecciencia.2013.14.9

[11] E. Magaña-Villegas, M. C. Díaz-López, S. Ramos-Herrera, J. M. Carrera-Velueta, and O. J. Vilchis-Peralta, "Air quality trend and proposal of a web application for the atmospheric monitoring network in tabasco, méxico.," *Tecciencia*, vol. 15, no. 28, pp. 15–27, 2020. **DOI:** 10.18180/tecciencia.28.2

[12] M. Pedroza Torres, E. Mariotte Parra, J. E. Quiroga, and Y. A. Muñoz, "Comparative analysis between som networks and bayesian networks applied to structural failure detection," *Tecciencia*, vol. 11, no. 20, pp. 127–140, 2016. **DOI:** 10.18180/tecciencia.2016.20.7

[13] A.-L. Barabási and E. Bonabeau, "Scale-free networks," *Scientific American*, vol. 288(5), pp. 60–69. https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.74.47.

[14] A.-L. Barabási and M. Pósfai, "The barabasi-albert model," *Network science, Cambridge University Press*. https://assets.cambridge.org/97811070/76266/frontmatter/9781107076266_frontmatter.pdf.

[15] C. M. Jérôme Kunegis, Marcel Blattner, "Preferential attachment in online networks: Measurement and explanations," *WebSci'13 Conference, Paris*. https://arxiv.org/abs/1303.6271.

[16] X. Polanco, *Redes de conocimiento: Construcción, dinámica y gestión*. 01 2006.

[17] J. A. H. Agata Fronczak, Piotr Fronczak, "Mean-field theory for clustering coefficients in barabási-albert networks," *Physical Review E*, vol. 68(4), p. 1. https://journals.aps.org/pre/abstract/10.1103/PhysRevE.68.046126.

[18] R, "The r project for statistical computing." Available at: https://www.r-project.org/, consulted on September 17 Jul. 2020.

[19] C. S. Gillespie, "Fitting heavy tailed distributions: the powerlaw package," *Journal of Statistical Software*, vol. 64(2), pp. 1–16. https://www.jstatsoft.org/article/view/v064i02.

[20] A. Canty and R. BD, *boot: Bootstrap R (S–Plus) Functions*, vol. 1. 01 2012.

[21] A.-L. Barabasi, "Linked: how everything is connected to everything else and what it means for business, science, and everyday life," *New York ; London: Plume*. https://www.researchgate.net/profile/Albert-Laszlo-Barabasi-2/publication/220694277_Linked_How_Everything_Is_Connected_to_Everything_Else_and_What_It_Means_for_Business_Science_and_Everyday_Life/links/547c51540cf2a961e48a010d/Linked-How-Everything-Is-Connected-to-Everything-Else-and-What-It-Means-for-Business-Science-and-Everyday-Life.pdf?origin=publication_detail.

[22] R. Albert and A.-L. Barabási, "Statistical mechanics of complex networks," *Rev. Mod. Phys*, vol. 74, p. 47, 2002.

A | APPENDIX. TECHNICAL COOPERATION THROUGH THE INDUSTRIAL KNOWLEDGE BANK 2009.

TABLE 2 Technical Cooperations realized throughout 2009, the cooperating institutions and countries, industrial sectors, namely agro-industry and the specific area.

Country	Donor entities and Receiving entities	Providing expertise in:
Venezuela - Perú	-Chamber of small, medium Enterprises and crafters from Lara Venezuela. -SME Asociación para el Desarrollo del Entorno Perú.	Transfer of better practices and techno-productive capabilities
Austria - Barbados/Dominica	-CONA-Austria Entwicklungs Handelsgesellschaft . -UNDP Sta Lucia, Barbados, Dominica.	Solar drying of fruits and vegetables: transfer of better practices (course for women)
Ecuador - Bolivia	-ENTERPRISE Paja Toquilla, Ecuador. -Woman NGO Tres Palmas, Bolivia.	Production chain for the manufacture of hats: evaluation, training, harvesting and preparation of the fibre (Jipijapa)

TABLE 3 Trade capacity building 2009.

Country	Donor entities and Receiving entities	Providing expertise in:
Jamaica - Suriname	-Innovative Project Solutions Ltda-SELA-Jamaica. -Ministry of Industry and Commerce, Suriname.	Policies and measures for SME development
Venezuela - Suriname	-SELA-IBERPME - Venezuela. -Ministry of Industry and Commerce, Suriname	Consultancy in policies and measures for the development of SMEs
Brazil - Trinidad and Tobago	-Centre for Strategic Studies and Management (CGEE), Brasilia, Brazil. -Ministry of Industrial Development and Commerce, Trinidad and Tobago.	Consulting, Industrial Development Policy

TABLE 4 Energy and the environment 2009.

Country	Donor entities and Receiving entities	Providing expertise in:
Argentina - Peru	-The Argentine Normalization Institute IRAM, Argentina Eco-efficiency and social responsibility SME centre. -Group GEA, Peru.	Standardization of the quantification, reporting and removal of greenhouse gases
Colombia - Peru	-Colombian Environmental Control Agency, Colombia. -Peruvian Environmental Control Agency, Peru.	(Organic and inorganic) solid waste usage and consulting.

A.1 | Technical Cooperation through the Industrial Knowledge Bank 2010

TABLE 5 Technical Cooperations realized throughout 2010, the cooperating institutions and countries, industrial sectors, namely agro-industry and the specific area.

Country	Donor entities and Receiving entities	Providing expertise in:
Nicaragua- Cuba	-CONA- Nicaragua Entwicklungs Handelsgesellschaft. -Nicaragua, Ministry of Food Industry of Cuba.	Enhanced practice transference in the field of fruits and vegetables solar drying for women
Argentina- Paraguay	-National Institute of Industrial Technology INTI-Argentina. -Ministry of Industry and Commerce Paraguay	Product diversification of banana candy, fruit pulps and juices. Processing, training and development of new products
Argentina- Paraguay	-National Agricultural Technology Institute-INTA-Argentina. -Paraguayan Center for Productivity and Quality CEPROCAL, Paraguay.	Training in better agricultural practices. Fruit, horticulture and livestock, depending on the requirements of national and international trade of products
Cuba- Paraguay	-Cuban Association of Artisans and Artists, Cuba. -Ministry of Industry and Commerce Paraguay.	Technical assistance in craft production chain: standardization of sizes and designs (hats and handcrafted furniture)
Brazil- Colombia	-Association and Cluster Bio-Ethanol Producers (APLA), State of Sao Paulo, Brazil. -Government Villavicencio, Colombia	Agribusiness, biofuels and food: strategies to support rural productive development

TABLE 6 Trade capacity building 2010.

Country	Donor entities and Receiving entities	Providing expertise in:
Cuba- Equatorial Guinea, Africa	-National Bureau of Standards and Quality Control-Cuba. -Ministry of Industry Mines and energy - Equatorial Guinea	International consultancy for the creation of the office of standardization and industrial quality control
Paraguay-Nicaragua	-Ministry of Industry and Trade, Paraguay. -Production Secretary Industry and Trade, Nicaragua.	Technical assistance to review, update and implement the development plan of the South Atlantic Region (RAAS)
United Kingdom-Argentina	-Department of Pharmaceutics University of London. -National Institute of Industrial technology - INTI-Argentina	Nano-technological systems for pharmaceutical, cosmetic and veterinary applications

TABLE 7 Energy and the environment 2010.

Country	Donor entities and Receiving entities	Providing expertise in:
Argentina- Mexico	-Argentina Wind Energy Association Latin - American. -Wind Energy Association, México.	Building of wind turbines and installation of wind farms; training for the creation of a value chain in the LAC region
Austria-OECS Member Caribbean	-ENPROCON, Austria. -OECS Member Caribbean States.	Technological innovations

A.2 | Technical Cooperation through the Industrial Knowledge Bank 2011

TABLE 8 shows the Technical Cooperations realized throughout 2011, the cooperating institutions and countries, industrial sectors, namely agro-industry and the specific area.

Country	Donor entities and Receiving entities	Providing expertise in:
Colombia-Paraguay	-Teucali Flowers, Colombia. -Ministry of Industry and Commerce, Paraguay.	Value chain and product certification
Argentina- Ecuador	-Technological University of Rosario, Argentina-Government of the Province of Pichincha-Ecuador	Value chains in the food sector: An update on the use of ICTs (Information and Communication Technologies)
Chile- Ecuador	-Regional Productive Development Agency de los Lagos, Chile. -Government of the Pichincha, Ecuador.	Value chain and product certification
Spain- Argentina	-University of Barcelona, Spain. -INTI-Argentina	Transfer of improved production practices and trends in cosmetics, food and chemical information about food
France- Peru	-ECTI, France. -Chamber of Commerce of Cusco Peru.	Training as part of a training program for the Chamber of Commerce of Cusco Peru on competitiveness, sustainable management

TABLE 9 Trade capacity building 2011

Country	Donor entities and Receiving entities	Providing expertise in:
Costa-Rica, Colombia-Paraguay	-Ministry of Agriculture-Colombia Ministry of Economy, Costa Rica SELA Paraguay	Development training for SMEs in Latin America and the Caribbean, experiences for public policy development
Brazil- Paraguay	-Technological Incubator of Popular Cooperatives, Brazil-SELA-Iberpyme	Training in marketing and market research, internal standards consortia
Chile- Guatemala	-Commercial Connections-Chile, EEUU-SELA Iberpyme Guatemala	Training in best practices and methodologies for development of entrepreneurship
Brazil- Mexico	-Ministry of Development, Industry,Brazil-Center for Investment, Mexico	Training in attracting investments, strategies and procedures to generate interest and culminate projects
Brazil- Guatemala	-Ministry of Development, Industry and Foreign Trade, SELA, Guatemala	Promoting entrepreneurship and enterprise

TABLE 10 Energy and the environment 2011

Country	Donor entities and Receiving entities	Providing expertise in:
Austria- Costa Rica	-PE International, Austria- Camara de Exportadores de Costa Rica (CADEXCO)	Cleaner production and carbon neutrality, environmental responsibility
Argentina- Nicaragua	-National Institute of Industrial Technology INTI - Argentina- Cleaner Production Center of Nicaragua	Environmental impact study to analyse the feasibility of a landfill site on the island of Omepete.

A.3 | Technical Cooperation through the Industrial Knowledge Bank 2012

TABLE 11 shows the Technical Cooperations realized throughout 2012, the cooperating institutions and countries, industrial sectors, namely agro-industry and the specific area.

Country	Donor entities and Receiving entities	Providing expertise in:
Brazil-Ecuador	-Tetrao Ind. E Com. de, Brazil. - MYPIMES, Ecuador	The renewal of the market, forest use, furniture design
Argentina- Bolivia	-National Agricultural Technology Institute, Argentina. -UEP "Programa Semilla“ of United Nations, Bolivia.	Parameters of quality, sanitary condition of herd, innocuousness of cheeses
Ecuador-Bolivia	-Ministry of Industries and Productivity, Ecuador. -UEP "Programa Semilla" Bolivia.	Commercialization of cultural products and eco-tourism (course for women)
Italy-Argentina	-Design Innovation, Italy. - National Institute of Industrial Technology, Argentina	Technical training about territorial information, analyses of productive history, design of strategies to increase value and local productive quality
Spain-Argentina	-PRODINTEC, Spain. -National Institute of Industrial Technology INTI, Argentina	Software Technologies "Rapid prototyping"
Ecuador- Bolivia	-Industrial chamber, Ecuador. -Autonomous Government Department of Tarija, Bolivia.	Consultancy about departmental plan of industrial and productive development

TABLE 12 Trade capacity building 2012

Country	Donor entities and Receiving entities	Providing expertise in:
Spain-Trinidad and Tobago	-Redegarantías, Spain. - International Financial Centre and SELA.	Implementation on SMEs
Brazil, Costa Rica - Venezuela	-Federal University of Rio de Janeiro, Brazil. -PARQUETEC, Costa Rica. - University Barquisimeto, Venezuela	Parks and Business Incubators

France-Bolivia	-ECTI, France. -Departmental Government of Santa Cruz, Bolivia.	Promotion of industrial sector strategies (industrial parks)

TABLE 13 Energy and the environment 2012

Country	**Donor entities and Receiving entities**	**Providing expertise in:**
Honduras-Venezuela	-Centre of Cleaner Production, Honduras. -Industrial Chamber of Carabobo, Venezuela.	Sustainable development
Spain-Ecuador	-IDAE, Spain. -MIPRO Ministry of Industry and Productivity, Ecuador.	Industrial Energy Efficiency
Mexico-Costa Rica	-National Institute of Statistics and Geography, Mexico. -CENIGA, Costa Rica	Calculating the green GDP gross domestic product

A.4 | Technical Cooperation through the Industrial Knowledge Bank 2013

TABLE 14 shows the Technical Cooperations realized throughout 2013, the cooperating institutions and countries, industrial sectors, namely agro-industry and the specific area.

Country	**Donor entities and Receiving entities**	**Providing expertise in:**
Austria-Paraguay	-CONA, Austria. -Ministry of Industry and Production, Paraguay	Enhanced practice transference in the field of fruits and vegetables solar drying
France-Argentina	-Futuribles, France. -National Institute of Industrial Technology INTI, Argentina	Science and Technology
Spain-Argentina	-Association Internationale de Prospectivae, Spain. -National Institute of Industrial Technology INTI, Argentina	Science and Technology
Argentina-Peru	-Instituto Nacional de Tecnología Agropecuaria,INTA Argentina. -Centro de Innovación Tecnológica Vitivinícola, CITEvid, Peru	Better productivity in the wine sector, Transference of knowledge and agricultural machinery
Chile- Ecuador	-FEDECCAL, Chile. -Cámara Nacional del Calzado del CALTU, Ecuador.	Transfer of best production practices in the tanning industry
El Salvador- Ecuador	-CONA, El Salvador. -PROECUADOR, Ecuador.	Functioning of solar plants, finance, commercialization and business plans
Colombia- Ecuador	-Servicio Nacional de Aprendizaje SENA, Colombia. -MAGAP y PRONERI, Ecuador.	Design of ovens for a better production of „panela granulada“ sugar

Mexico- Argentina	-Silliker-México Sa de CV, México. -National Institute of Industrial Technology INTI, Argentina.	Decomposition of foodstuffs and influence on stability and life
Spain-Peru	-CITEagroindustria Spain. - Instituto Tecnologico de la Produccion ITP, Peru.	Economic and financial management

TABLE 15 Agro-industry 2013

Country	**Donor entities and Receiving entities**	**Providing expertise in:**
Colombia-Ecuador	-Environmental control Agency, Colombia. -Instituto Ecuatoriano de Normalización, INEN, Ecuador.	Handling of residues, drainage, design, management of waste
Spain - Colombia	-ZICLA, The Catalan by-product exchange, Spain- Centro de Producción más Limpia, Medellín, Colombia	Recycling exploitation of residues, industrial processes, industrial ecology, energy and environment