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Characterization of the Cuban biopharmaceutical industry from collaborative networks

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Abstract Studies of scientific collaboration have introduced the concepts of collaborative networks. These networks may represent the social structure of a community of researchers or knowledge transmission in a specific country or economic sector. Cuban biopharmaceutical industry is an exceptional case study. This high-tech sector has achieved important development in the context of a "Third World" country, with a different political organization from the rest of the world. The main goal of this work is to characterize the Cuban biotechnology industry using collaborative networks. WoS database (1969–2016) was used and metric indicators of scientific collaboration obtained from the affiliation field. Netlike visualizations were produced with NodeXL software. BioCubaFarma meets about 50% of the total scientific production of all Cuban sectors. Since its foundation, the sector has maintained significant internal and external collaboration, with Europe, Latin America and the United States of America. The United States collaboration has been significant in the absence of diplomatic relations with that country. Collaboration is greater among centers

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of the old "scientific pole" than among old companies of the pharmaceutical sector. Moreover, there is a correlation between the magnitude of the scientific production and the collaboration levels. For the development of biomedicine in Cuba, collaboration has not been solely endogenous but has also represented a significant transfer of knowledge between Cuba and other countries.

Keywords Collaborative networks · BioCubaFarma · Biopharmaceutical industry · Community of researchers · Scientific collaboration

Introduction

Current scientific development entails finding solutions to complex problems, causing researchers to coordinate their individual efforts and turn them into collective ones. This requires the implementation of collaborative processes where, starting from the contribution of several creative ideas, there follows a search to produce results to a problem or research question. Various authors (Peres 1966; Newman 2001; Jang and Ko 2017) have studied the increase in scientific creativity, teamwork efficiency and scientific progress related to collaborative interactions established between experts of a field, whether it is at the institutional, national or international level.

Cooperation includes contact and coordination tasks (Wagner and Leydesdorff 2005), meaning that two scientists collaborate when they share data, teams and ideas in a research project that could later produce experimental practices and research analysis, whose results may well be published in the form of an article (Katz and Martin 1997). A published paper will have authorship or co-authorship and the authors that contributed to the published documents in a determined field, will form a population. When that population is studied, behavioral patterns emerge in the form of individual or collective authors. Therefore, collaboration can be studied from analysis of co-authorships (Glänzel and Schubert 2004).

Metrics, namely, bibliometrics, scientometric, infometrics and webmetrics, etc., as metric models of science have been used by various authors to study collaboration, starting from co-authorship or the geographical affiliation of authors, such as Begum and Sami (1988), and later by Moed and Halevi (2014), Glänzel et al. (2016), Hottenrott and Lawson (2017), among others. These models have been strengthened by advances in visualization techniques within metric studies and the application of social network theories, which have enabled the introduction of collaborative network concepts and the representation of the social structures of a scientific community (Crane 1977; de Solla Price 1963). From the decade of the sixties, de Solla Price and Beaver (1966) studied authorship in collaboration as an indicator of social links and in this way, was able to analyze invisible colleges and homogeneous groups. Price stated that the interaction between scientists is the essence of current scientific practice, and it is the collaboration networks that paved the way to fruitful and profound transdisciplinary research.

A review of the literature on this topic, retrieved a number of articles that studied the incidence of Cuban scientific collaboration identified by using metric indicators. For instance, De Moya-Anegón and Herrero-Solana (1999) analyzed the collaboration of Cuba compared to the rest of the Latin American (LA) countries. These authors show that the percentage of co-authorship in the case of Cuba is a scarce 4%. Consequently, a low collaboration index is evidence of the scientific isolation of Cuba. Rodríguez et al. (2007) analyzed, among other factors, collaboration in the field of social sciences. While Aguado et al. (2009), using the Redalyc database (http://www.redalyc.org/) provide an analysis of the patterns of collaboration through co-authorship networks for five journals published by the Autonomous University of State of Mexico. Arencibia-Jorge et al. (2016) characterized the biopharmaceutical sector by considering the "International Collaboration Index" provided by Scimago, which is based on Scopus data. However, the study did not look deeply into the analysis of the collaboration networks of the sector. No collaboration studies focused on the Cuban biopharmaceutical industry were found covering a long period such as the 47 years of scientific research (1969–2016) in the present study nor using the Web of Science (WoS) as the data source.

The main objective of this paper is, therefore, to characterize the Cuban biopharmaceutical industry using the collaboration networks as its basis. Emphasis is placed on the patterns of collaboration which paved the way to the former "Scientific Pole", its relation to the academic world and to research centers of the United States and Europe, as well as the channels of transmission of scientific knowledge used by the groups with the highest indexes of collaboration.

The analysis of this sphere of knowledge is essential, not only for Cuba, but for the rest of the world (Evenson 2007; Lage 2012). According to Thorsteinsdóttir et al. (2004), the development of biomedicine needs human resources, materials and accumulated scientific knowledge, making it difficult for small countries with scarce economic resources to compete on a global scale. Nonetheless, Cuba is an exception, the products and services related to biomedicine are currently the second major export of this country and some of the products are world pioneers (López et al. 2006).

The study of the factors that have influenced this success and a deeper understanding of this phenomenon could provide clues to the knowledge structures and links that are established in science and especially under special development conditions, as is the case with Cuba.

Cuban biopharmaceutical industry: background

At the beginning of 1959, Cuban scientific research was marked by the new political context. An ambitious strategic program was created to promote national scientific development (Castro 1990; García-Capote 1999, 2015). This program was considered ambitious, considering the disparity between the objectives of the project and the limited national scientific and technological resources (Le Riverend 1971).

The first stage of scientific development is characterized by the training of a critical mass of human resources dedicated to Research and Development (R&D) that could devote themselves to the attainment of results. In the institutionalization of science, for instance, from 1962 to 1973, the Academy of Science (1962) was created, as well as 53 other Research and Development (R&D) entities in areas that range from exact and natural sciences to medical, technological, agricultural and social sciences (García-Capote 1999).

The first steps were taken in mid-1980s with the creation of the so called "Biological Front" (López et al. 2006). This would mark a turning point in Cuba's commitment to R&D: the combination of these two factors, coupled with the availability of a core human potential, would motivate Cuba to develop the scientific establishment further and expand its base into the national economy. This heralded the beginning of accelerated research in molecular biology and genetic engineering. Over a period of 20 years or so, the Cuban government invested around US$1 billion to develop the country's first and most important science node—that of West Havana—comprising 52 institutions and enterprises related to biotechnology, covering research, education, health, and economics. Ten institutions form the core of this node, in that they support the entire effort financially through their production capacities and exports (UNESCO 2010).

In 2008, these ten institutions were carrying out more than 100 research projects, mainly related to biotechnology applied to human health. These have generated a product pipeline of more than 60 new products. Intellectual property rights protect most of these products and more than 500 patents have been filed abroad. Ten Cuban scientific results have been awarded the World Intellectual Property Organization (WIPO) Gold Medal (UNESCO 2010).

It is precisely, during this period, when the Biotechnology sector is created, and the greatest results are attained. At the end of the 1980s the country suffers an economic crisis that was called the "Special Period". Nonetheless, the development of the sector continued in spite of the prevailing situation, which shows the political will in maintaining its strategic line and an exclusive budget was granted to preserve the achievements reached.

In 2012, the biotechnological sector is merged with the pharmaceutical sector, both being financed by the State, with the aim of creating a Higher Organization of Entrepreneurial Development (OSDE according to its Spanish acronym) called BioCubaFarma (Council of Ministers 2012).

Data sources and data processing

The source of information used to conduct the current research was the main collection of Web of Science (Web of Science Core Collection, WoS), available through the ISI Web of Knowledge platform of Clarivate Analytics (https://clarivate.com/). This database contains information on multidisciplinary research published in world's mainstream journals of science, social sciences, art and humanities and regarded as one of the most important sources for bibliometric studies.

Data were collected was from 1969 to December 2016, using the search by country strategy (CU). No limits were established, not language, nor type of document in the algorithm search. The records were exported from the WoS in full format using the *Save to Plain Text* option and imported to a Database (DB) called CubaWoS to enable the processing of the information.

Database standardization and BioCubaFarma domain

The units of fundamental analysis were the data contained in the field addresses of the authors. The structure of the addresses makes it possible to study collaboration using countries, cities and main organizations as the units of investigation. The information provided by other fields of the bibliographic records enabled us to limit the study to a certain period by using the publication year of the article, or to a given field by using the journal name. The journals can be arranged into journal subject categories, sub-fields or major fields (Melin and Persson 1996).

The DB CubaWoS was administered in the ProCite Database Bibliographic Manager, which enabled the standardization. The next procedure was the normalization of the institutional names listed in the Address (AD) fields in the bibliographic records. The search equation for the recovery of papers comprised the different names of the institutions in the field of affiliation (within the limits of DB CubaWoS in ProCite). All countries and institutions indicated in the address field were considered.

As a second step, the publications gathered from ProCite (Group Option) were only those that contribute to the thematic areas of the biomedical sector according to the criteria developed by Glänzel and Schubert (2003), who established a classification of published papers based on the field assignment of journals. The BioMed-WoS group (11,163 publications) was produced with the papers belonging to the following fields: Biology, Biosciences, Biomedical Research, Clinical and Experimental Medicine I (General and Internal Medicine), Clinical and Experimental Medicine II (Non-Internal Medicine Specialties) and Neuroscience and Behavior.

Finally, the BioCubaFarma-WoS group was formed (3852 publications) by the scientific production of the institutions belonging to this sector. For its creation, CubaWos was interrogated with all the possible nuances and variants of the names of the centers that are part of the current Cuban biopharmaceutical industry and were given a classification. Global changes were made for this group and the field of affiliation was standardized with the ProCite tool (Database/Global/Find/Replace). Long names of institutions were shortened with the acronyms for which they are known (see "Appendix").

Data processing and indicators

Total productivity indicators of the country, in this case Cuba (CubaWoS) and two of the selected groups (BioMed-Wos and BioCubaFarma-WoS) were calculated. In addition, the percentage of papers written with international collaboration (percentage of papers written with at least two authors whose affiliation are in different countries) was calculated, as well as the percentage of papers written with national collaboration (percentage of papers written by at least two authors whose affiliations are different but belong to the same country). In addition, the percentage of papers written without collaboration (papers written by authors that have a same affiliation) was determined.

Looking deeper into the behavior of the levels of BioCubaFarma's collaboration, the national collaboration index (IC-National) was calculated, considered as the sum of the different affiliations of national origin that sign papers per year of publication. The international collaboration index (IC-International) corresponded to the sum of the different affiliations of international origin that sign papers per year of publication.

The Collaboration Indexes per geographical area were attained by considering the Index of European Collaboration (IEC) as the total of the different country affiliations pertaining to the geographical area, as shown in the affiliation field. The same criterion was followed to calculate the Collaboration Index of Latin America and Asia. A country thesaurus was used to identify the countries and regions and a text mining technique applied for the field of affiliation. This is one of the modules developed using the ViBlioSOM methodology (Sotolongo et al. 2002).

Likewise, networks of country and institutional collaboration were built using the centrality measures. Techniques from the analysis of social networks were used (Scott 1991) employing the NodeXL program (https://nodexl.codeplex.com/). Centrality is one of the classic measures used in metric studies. In a social network, degree centrality of a node represents the number of node connections with the other constituent nodes of the network. In other words, in a collaboration network, degree centrality of any element represents the number of countries or institutions that collaborate with the other countries or institutions in the network (Newman 2004). The N will be the notation of the total number of publications producing the network. This tool is a complement to Microsoft Excel, which enables the visualization and the analysis of graphs. The data are dealt with in a template that is managed just like the rest of the Excel data.

Results and discussion

Figure 1 shows how long it takes a country, which has changed its economic and political orientation, to attain desirable levels of scientific production. Considering that the desired level of scientific activity is larger than one thousand papers a year, which were reached after the year 2000. That same year, the correlation coefficient between total number of publications and total number of researchers (according to the register of the Academy of Science of Cuba) was 4.48 documents (Oficina Nacional de Estadística e Información [ONEI] 2016).

In 1981, Cuba published nearly 200 papers in all scientific disciplines and practically half belonged to biomedical disciplines. The biotechnological sector and pharmaceutical industry were one, at that time only the National Scientific Research Center (CNIC) existed, which was founded in 1965. Back then, this institution was under the umbrella of the Ministry of Higher Education and later, it was incorporated into BioCubaFarma due to the mission and the role that it began to play in the biopharmaceutical sector.

The "Biological Front", predecessor of BioCubaFarma, reached 100 publications in the year 1998. In scarcely 10 years, scientific results were attained and published in "mainstream" journals, while it took the institutions that form part of the rest of the groups, a longer period (27 years) to achieve the same level of publication. At that time, the "Biological Front" was formed by small groups of scientists belonging to different research centers, national institutes and university faculties that had already been created and were working on important projects for the country. The "Biological Front", formed by 10 institutions, began to produce about half of all the biomedicine scientific production of the country.

The analysis of the decade of the 1990s, could be defined as one of growth and consolidation but after the year 2000, production reaches a plateau or period of stagnation

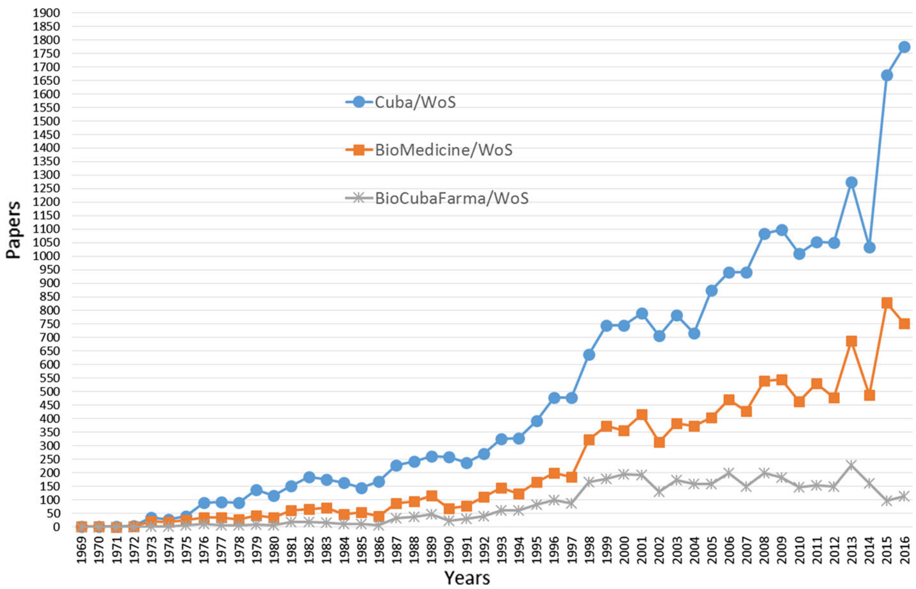

Fig. 1 Comparison of total Cuban scientific production, in biomedicines and of BioCubaFarma in the WoS

with an annual output of approximately 200 papers. The "closed cycle" strategy, implemented in the "Scientific Pole", was consolidated at the end of the 1990s (1997–1999). This may be supported, among other factors, by the increase in products registered and marketed nationally or internationally. Between 1981 and 1990 there were three products approved by the State Center for the Control of Medicines (CECMED). From 1996 onwards and until 2000, this number was increased by 38 new products obtained with high technology processes.

Up to 2016, the centers that form part of BioCubaFarma and that previously belonged to the Scientific Pole, were responsible for 34.7% of the country's scientific production in biomedicine and 16% of the total production of the country which constitutes an important percentage, considering that it was formed by a mere ten R&D organizations. Although Cuban scientific production in general has continued to grow in the last two years, in the biopharmaceutical sector there has been a decline (2015–2016).

Figure 2 shows how the gap widens between all Cuban publications in biomedicine and that which the BioCubaFarma centers produce. During the decade of the 1990s it was nearly 50% and currently (2016) it's about 15%, just about the same as at the beginning of the decade of the 1980s. This initial production was provided, basically, by two organizations that today form part of the sector: Centro Nacional de Investigaciones Cientificas (CNIC) and the Center for Neurosciences.

The aforementioned behavior coincides with the scientific development data registered in the Statistical Yearbook of Cuba (ONEI 2016), which contains data up to 2015. The statistics showed an 11% decrease in the total number of persons working in the "Science and Technology" sector, with a decrease of 1019 researchers in 2015 in comparison with the 3853 researchers in science in 2011.

With respect to current expenditures devoted to science and technology activities by source of financing, the state budget has decreased the amount dedicated to R&D but has increased the sum devoted to entrepreneurial investment. However, the total scientific production of Cuba has increased in the past few years which could result from a shift from research and publication towards other areas or sectors, such as universities and institutions of the public health sector.

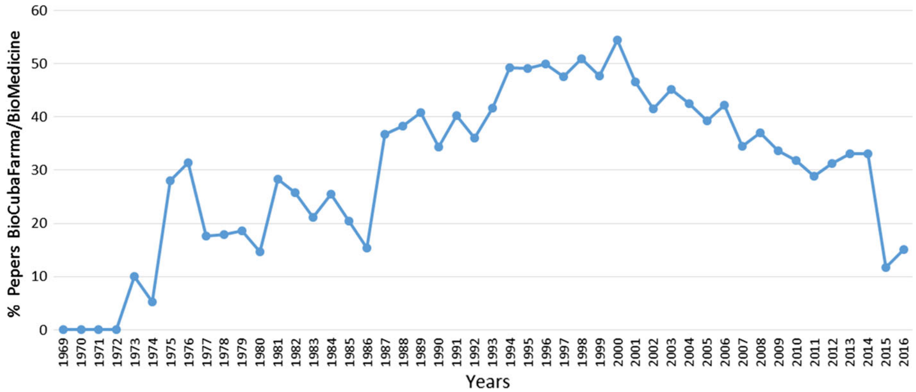

Fig. 2 BioCubaFarma's scientific production in Biomedicine as a percentage of total Cuban production in this field in the WoS

National and international collaboration

In spite of the isolation of Cuban science in the international sphere, the percentage of papers published in collaboration (68%) has been greater than those published without collaboration (32%), the majority of which has been written with international collaboration (40%). The largest number of papers published without collaboration are found in the first years of the period of analysis (1969–1980). This may be a logical consequence of the time when the National System of Science and Technology still lacked a political projection with respect to the development of biotechnology in the country.

Figure 3 shows that IC-International has been slightly higher than the national equivalent, 26.7% in comparison to the 37.3% of papers written with a non-Cuban author. Two periods are highlighted where IC-International showed significant behavior with respect to IC-National. The first period between 2001 and 2007, when the IC-National which was showing fairly uniform behavior, moves away from IC-International and surpasses it. However, from 2012 to 2016, the IC-International significantly surpasses the IC-National.

Scientific collaboration has been developed with Latin American countries as well as with Europe and with the United States and Canada. Figure 4 shows the organizations that belong to BioCubaFarma (circles) and the countries with which collaboration has taken place (squares). The collaboration with Europe is headed by Spain (with 24%), other significant countries are England, Germany, and Italy that register 11, 12 and 10%, respectively. The lack of cultural and linguistic barriers with Spain may motivate the high level of collaboration.

In general, the index of European collaboration is greater (56%) than with Latin America (26%). LA countries that have highest levels of collaboration are Mexico (18%) and Brazil (10%). With Asia there is a collaboration index of 8%.

The broad cooperation of BioCubaFarma with Europe may be because biotechnology is an area that needs knowledge flows from leading high-tech countries. A report prepared by the Ibero-American Observatory of Science, Technology and Society of the Center for Advanced University Studies of the OEI (Organization of Ibero-American States 2013) concluded that appalling difference in the levels of development exist between Europe (and

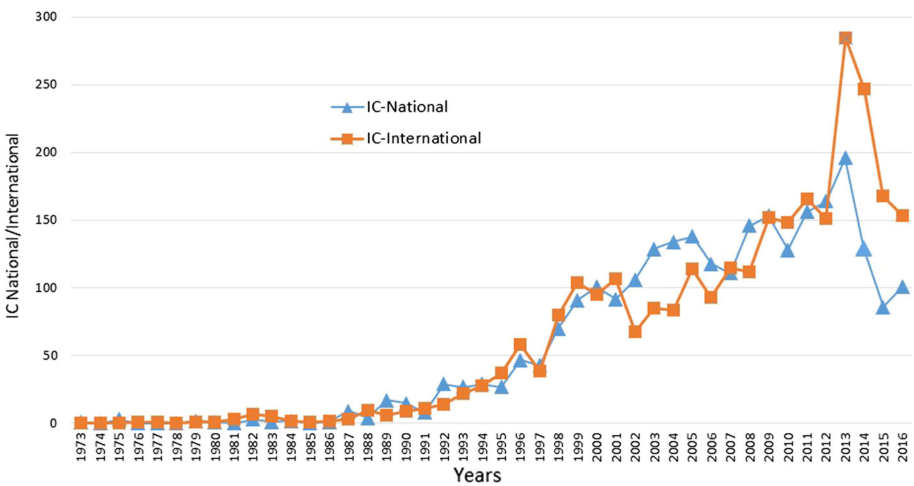

Fig. 3 BioCubaFarma Indexes of National and International Collaboration

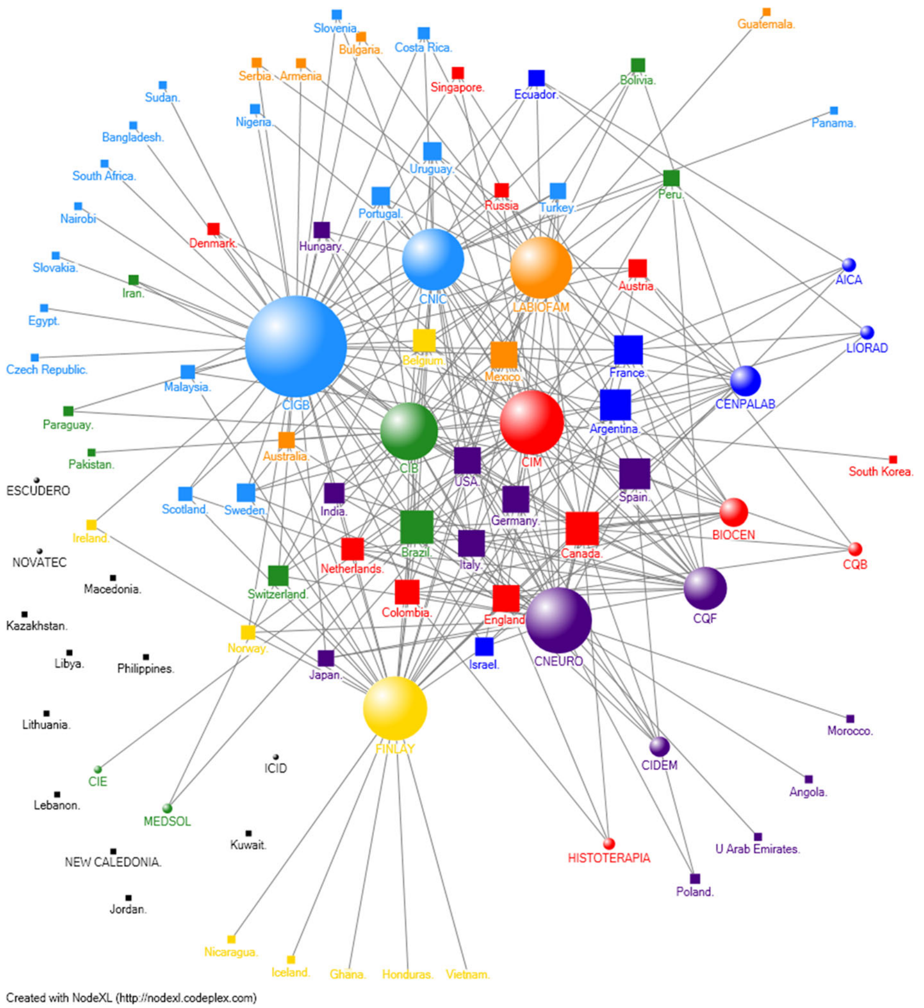

Fig. 4 Representation of International Collaboration. *Note* circles represent the institutions and squares the countries (N = 1542 publications)

particularly Spain) and the Latin American countries in the field of biotechnology. The results of our study indicate that BioCubaFarma took as a reference base for its expansion the most established countries with regard to industrial and scientific infrastructure. This underlines the hypothesis of Melin and Persson (1996) suggesting that small countries need to establish external contact with countries with important developments and more consolidated systems.

It should be pointed out that in the absence of diplomatic relations between Cuba and the United States (USA), BioCubaFarma registers a 10% of studies with various institutions of that country. In general, this country accounts for 29% of collaboration, regarding the total Cuban scientific production registered in WoS during the period analyzed (CubaWOS—BD). This collaboration has been greater with Cuban institutions such as CNeuro (devoted to neurosciences), CIGB—Center for Genetic Engineering and

Biotechnology (with lines of research in the development of vaccines, interferon, and other drugs attained through genetic engineering techniques) and CIM—Center of Molecular Immunology (oncology).

The levels of collaboration are greater regarding the institutions of the former "Scientific Pole" or the biotechnological sector than in those of the pharmaceutical sector. As shown in Fig. 4, organizations such as MedSol, Aica, Liorad and CIDEM have lesser collaboration and are on the perimeter of the network (see the size of the circle and the position in Fig. 4). The rest of the institutions of the former pharmaceutical sector do not register any collaborative work.

Collaboration among the centers that constitute the sector is represented in Fig. 5. BioCubaFarma has emerged with a philosophy of strengthening collaboration between the institutions and sections devoted to biotechnology which arose from the Scientific Poles. They all considered as one of their purposes, collaboration of the high technology institutions with universities, other research centers and among themselves.

Of all the centers belonging to the sector, those arising from the pharmaceutical industry had less collaborative activity, while those that came from the Scientific Pole maintained a

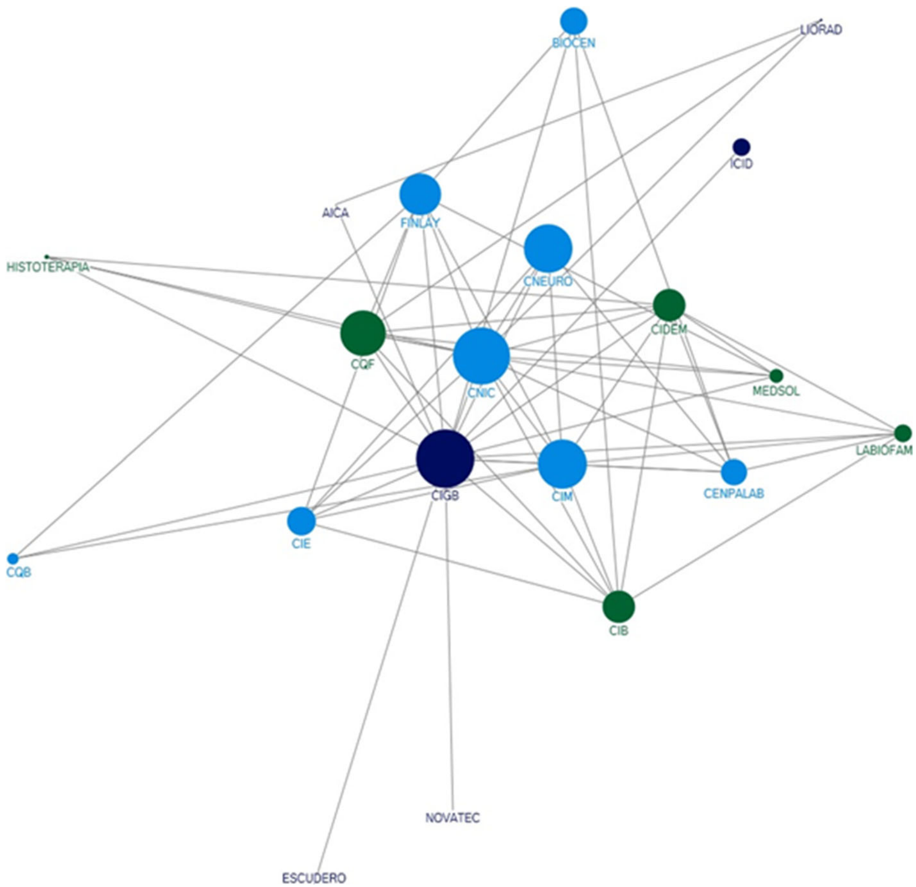

Fig. 5 Collaboration between the Institutions that form part of the BioCubaFarma sector ($N = 205$ publications)

greater level of collaboration and interactions among themselves. Three centers in the net, CIGB, CNIC and CIM, have maintained collaboration with practically all the institutions of the sector. However, CNIC has had greater collaboration with the former CQF, CQB, and CIB. CIGB has maintained its principal collaboration with CIM, which represents 31% of its total collaboration. In short, CNIC, CIGB, and CIM amass 22, 21 and 12% of all internal collaboration of the sector, respectively. This represents 55% of all internal collaboration. There are isolated institutions such as LIORAD, AICA, ESCUDERO, HISTOTERAPIA, ICID, and NOVATEC, all which maintain little collaborative activity, their total collaboration accounts for only 2,2% of the total.

The practice of Cuban biotechnology has been to implement a strategy that combines collaboration and flow of information with Latin American and European institution, mainly with universities as shown in Fig. 6. However, collaboration has been significantly greater with Spanish speaking institutions such as: the University of Barcelona, the UNAM (National Autonomous University of Mexico) and the University of Argentina, with which there is a total of 352 links. There are relations with several Brazilian institutions, such as the University of Sao Paulo. The Pan-American Health Organization (PAHO) (see Fig. 6, WHO) has played an important role in encouraging cooperation between European

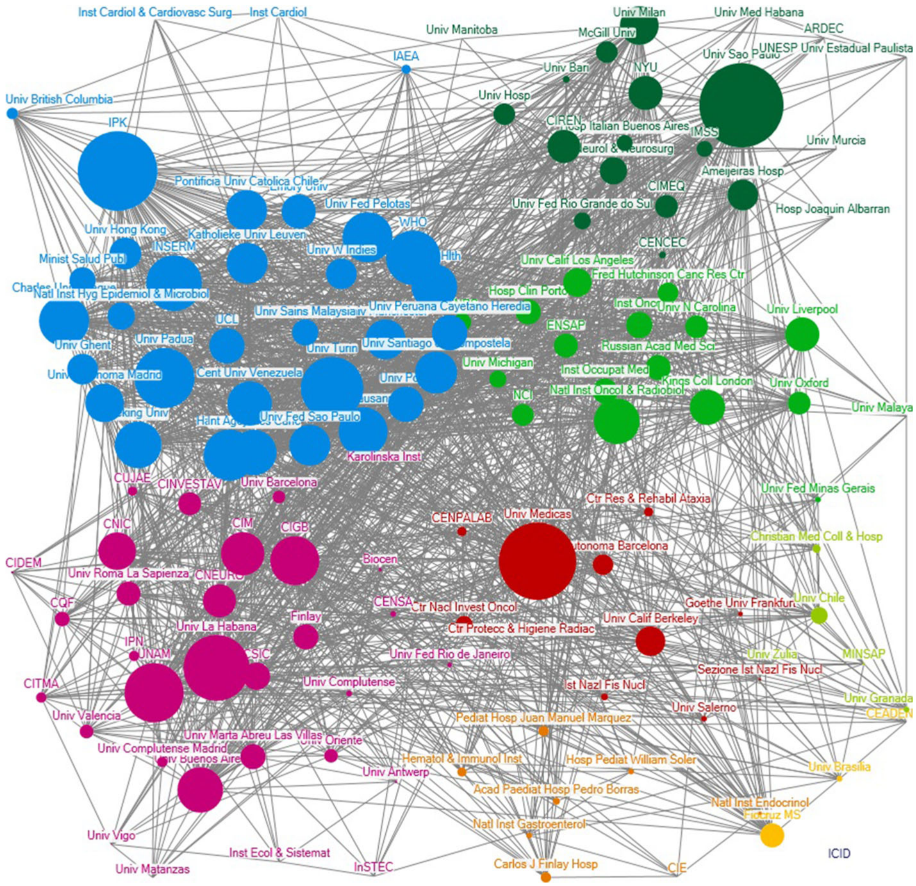

Fig. 6 Collaboration between National and International Institutions ($N = 2636$ publications)

countries and Cuba. Two hundred and three papers have been written with the participation of this international agency.

The link between the institutions of the sector and the rest of the country has been comprehensive. Collaboration has also taken place with universities. The University of Havana is the Cuban institution with the greatest collaboration with BioCubaFarma. The collaboration with institutions belonging to the Cuban Ministry of Public Health (MINSAP) is noteworthy. Collaboration with centers of this sector have been identified, like specialized hospitals such as the Institute of Tropical Medicine "Pedro Kouri" (IPK) and institutes devoted to oncology research (Institute for Oncological Research) and immunology (Hematological and Immunological Institute), as well as university medical centers, such as the Schools of Medicine.

The significant collaboration between BioCubaFarma and MINSAP, could be connected to the fulfillment of one of the objectives for the creation of first the "Scientific Poles" and later, BioCubaFarma. It was to encourage collaboration between the different scientific actors and above all, with the system of institutions of MINSAP. This is probably a peculiarity of the Cuban biopharmaceutical development, that a major policy of the sector is to contribute to the improvement of health and quality of life of the general population. Consequently, its achievements have repercussions, not only directly in the economy of the island, but also in the improvement of national health. BioCubaFarma accomplishes its economic mission when it impacts positively in the level of health of the Cuban population.

Just as Thorsteinsdóttir et al. (2004) mention, BioCubaFarma's "Closed cycle" or "Closed Loop" approach (Lage 2007), emphasizes transnational research and coordinates the whole process involving institutions—from research to commercialization—of a biotechnological product. An example of this is the success of the Cuban vaccine against *Haemophilus influenzae type b*, which was the result of cooperation between five institutions from different sectors (Public Health, Education and Biopharmaceutical Industry), namely, the University of Havana (UH), the Center for Genetic Engineering and Biotechnology (CIGB), the Finlay Vaccine Institute, the National Center for Biological preparations (BIOCEN) and the Institute for Tropical Medicine "Pedro Kouri" (IPK).

Conclusions

Scientific collaboration could be a solution when encountering research that cannot be approached individually but needs to be undertaken in groups. We have shown that this topic can be studied from the research results gathered in the database (published papers) and co-authors networks, which could be proof of the interactive strategy of the development of scientific research, above all, in the centers of high technology such as BioCubaFarma.

Our analysis clearly shows that Cuban biomedical production was practically nonexistent until 1972 and was swiftly developed after 1990. Originally, production was concentrated in the institutions that today are part of BioCubaFarma, but this has gradually shifted to other research groups of the country (not linked to the biopharmaceutical sector). Since the decade of the 1990s, BioCubaFarma has made an important contribution to the scientific production in biomedicine, equivalent to approximately 50% of the whole production of the other sectors of the country.

We find knowledge transference and communication at all levels (national and international). The percentage of documents produced in collaboration, published jointly by research teams from different national and international institutions, fourfold and fivefold during the study period. At the national level, greater research cohesion has been promoted between BioCubaFarma's institutions and those belonging to the Ministry of Public Health and academic institutions. This has had an effect on important collaboration with institutions of the health sector such as hospitals, research institutes of this sector and universities of medicine, and has demonstrated the close relationship that exists between research and health issues of the country, as well as the mutual links and influences between the State, society and the biopharmaceutical sector.

At international level, greater collaboration has taken place with European countries than with the closer geographical area of Latin America (considering shared language, interests, problems, etc.). BioCubaFarma has developed the capacity to adsorb and use the knowledge of European countries with more established scientific and technological systems to progress in the innovation of their own biopharmaceutical products. Knowledge transfer has been greater between universities and public research centers than with the private sector or the large international biopharmaceutical companies.

The absence of "official" collaboration between the United States and Cuba due to the political division between these countries after 1959, has not withheld the existence of an "invisible" or informal collaboration between groups of scientists, in reference to the concept of "Invisible College" provided by Crane (1977). Taking the above into consideration, we could affirm that in spite of the endogenous character of the program for the development of BioCubaFarma, it has been nourished by the science and knowledge generated in other parts of the world, above all, in novel themes such as neuroscience and vaccinology.

Considering that this type of study is valid for the analysis of the scientific-technological development of a country, it is recommended that this analysis be extended to the collaboration that is established in patents and other regional databases. For example, the SciELO Project, which perhaps shows a vision of the science published in journals with lesser impact (according to the impact factor of journals included in the WoS), but most probably with greater social impact.

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Appendix

See Table 1.

Table 1 Acronyms of the Cuban Institutions that are part of BioCubaFarma

Acronyms	BioCubaFarma institutions
1. AICA	Empresa de Laboratorios Farmacéuticos AICA
2. BIOCEN	Centro Nacional de Biopreparados
3. ESCUDERO	Empresa Laboratorio Farmacéutico "Roberto Escudero"
4. CENPALAB	Centro Nacional para la Producción de Animales de Laboratorio
5. CIB	Centro de Investigaciones Biológicas
6. CIDEM	Centro de Investigación y Desarrollo de Medicamentos
7. CIE	Centro de Inmunoensayo
8. CIM	Centro de Inmunología Molecular
9. CIGB	Centro de Ingeniería Genética y Biotecnología
10. CNIC	Centro Nacional de Investigaciones Científicas
11.. CNEURO	Centro de Neurociencias de Cuba
12.. CQB	Centro de Química Biomolecular
13.. CQF	Centro de Química Farmacéutica
14.. HISTOTERAPIA	Centro de Histoterapia Placentaria
15. ICID	Instituto Central de Investigación Digital
16. LABIOFAM	Grupo empresarial LABIOFAM
17. LIORAD	Empresa Productora de Insulina y Carpules LIORAD
18. MEDSOL	Empresa Laboratorios MedSol
19. NOVATEC	Empresa Laboratorios NOVATEC
20. INSTITUTO FINLAY	Instituto Finlay, Centro de Investigación-Producción de Sueros y Vacunas

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