CHARACTERISTICS OF NATIONAL INNOVATION SYSTEMS IN LATIN AMERICA TO TRANSIT TO KNOWLEDGE-BASED BIOECONOMY

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1.- Abstract

The knowledge-based bioeconomy, is a recent proposal by the Organization for Economic Co-operation and Development and the European Union, consists of transforming economic systems into knowledge-based (such as biotechnology) economies to create novel and efficient forms of biomass utilization, in order to overcoming dependence on fossil resources, and provides solutions to global problems such as food shortages and climate change, among others.

This paper presents a multivariate cluster analysis based on socio-economic, environmental and scientific-technological indicators to compare the different capacities of Latin American countries and to identify strengths (qualified human resources, infrastructure, among others) and weaknesses low investment in R&D, etc.) in the region to promote the transition to a knowledge-based bioeconomy. Once the countries with the greatest potential are identified, the economic sectors in which these nations have focused their bioeconomy strategies are analyzed and some examples will be given.

Among the results obtained, it was found that Argentina, Brazil and Mexico are the countries with the greatest potential in the region to move towards a knowledge-based bioeconomy. Argentina has focused its efforts on the agro-industrial sector, Brazil on biofuels, and finally, in the case of Mexico, no defined strategy is detected, but there are efforts in biofuels and in the new materials sector, but the potential of Mexico comes from the broad possibilities of developing goods and services in different sectors (such as health and new materials) of the knowledge-based bioeconomy, thanks to the infrastructure it has and its human resources in science and technology.

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These countries have superior capacities compared to other nations, mainly in human resources training, public and private expenditure on R&D and available infrastructure.

It was concluded that the bioeconomy in Latin America is a process that is only beginning following the trend of what is happening in other parts of the world, but some countries in the region have comparative advantages and potential that will allow them to migrate towards a knowledge-based bioeconomy. Other countries will require a significant effort to transform public policies and institutions to achieve this.

Three main areas of improvement are identified for the least potential countries. The first is the generation of highly qualified human resources in areas and sciences related to the knowledge-based bioeconomy. The second is that these countries have not developed specific government support programs (financing, infrastructure building, etc.) for the development of capacities in science and technology. Lastly, there is the pre-eminence of institutional and political deficiencies to promote a bioeconomy in the region that allows countries to insert themselves into the highest links of international value chains.

Key words: Knowledge-based bioeconomy, Sustainability, Capabilities

2.- Introduction

The development of the industrial revolution driven mainly by fossil fuels, has led many global problems today. It has also led to major innovations to improve social and economic conditions, but has also deteriorated the quality of life of citizens and ecosystems. This makes the current pattern of production and consumption unsustainable, putting the environment and the stock of natural resources at risk, so that several solutions have been proposed over more than four decades.

One such solution was proposed at the dawn of the 21st century, by the Organization for Economic Co-operation and Development (OECD) and the European Union (EU). This solution is the approach of the knowledge-based bioeconomy (KBB), since it has promoted the creation of new forms of sustainable production and consumption through various agents (academia, government, industry and civil society). The KBB is based on increasing the use of biological resources as the consumption of oil and coal is reduced.

The KBB seeks more than replacing CO_2-intensive energy sources that are neither sustainable or renewable as there are various opportunities for the design and production of new lines of product and services for final consumption as well as new efficient and sustainable processes through modification And transformation of biomass from scientific and technological knowledge (biotechnology, nanotechnology and in some cases of information and communication technologies (ICTs)) that would help solve major global problems such as lack of food, climate change, problems Health, etc.

KBB can be defined as an economy where the production of goods and services is derived from the transformation of living organisms (plants, animals, bacteria, viruses and enzymes) through scientific knowledge (bio and nanotechnology) to satisfy the needs of society with sustainable processes and products.

The KBB looking attend the requirements for sustainability of environmental, social and economic perspectives. The OECD in *The Bioeconomy to 2030: Designing a Policy Agenda* (2009) and the EU in *Innovating for Sustainable Growth: A Bioeconomy for Europe* (2013) indicate that some of the potential benefits of the transition to KBB include: reduction of greenhouse gases (GHG), reduction of dependence on fossil resources (oil), more prudent management of natural resources and contributing to food security.

Other positive effects of the transition to KBB are the creation of jobs in rural and urban environments, the creation of new non-food markets for agriculture (such as biofuels) in synergy with existing food markets and in combination with other sources of income for farmers, which can give a great boost to improving the socio-economic conditions of rural areas, particularly in developing countries.

There are international agreements to urgently carry out the transition from current economic systems to the KBB at the global (OECD, 2009) and regional (European Commission, 2012), (ECLAC, 2015). However, given the different levels of development (economic, scientific and technological, etc.), some national economies may not be prepared (given their capacity to develop innovations) to use strategies such as the bioeconomy. Within the context of the learning economy Lundvall (1992) says that some countries and their systems of innovation historically, are better prepared to deal with a new technological context (such as the knowledge-based bioeconomy) than others. Since the use of scientific and technological knowledge is fundamental for the development and/or improvement of biomass-based goods and services, this assumption is also valid for the transition to a KBB. However, it should be mentioned that if countries that do not have the scientific and technological characteristics and capacities sufficient and necessary to adopt the KBB can relegate regions such as Latin America to a function of simple producers and suppliers of biomass that in little contribute to the economic, social and technological development of the countries in the context of the bioeconomy.

It is important to carry out studies to determine the present state of the developing region countries to determine the current state of their capacity to face the challenge of adopting a new production context such as the bioeconomy, thus identifying strengths and weaknesses that allow development Strategies to promote and attack and solve the other.

This paper examines the different national conditions for the transition to a KBB within nineteen countries of the Latin American region, empirically analyzing and comparing the capacities and context of specific national innovation systems (NIS) for KBB. Section one presents the theoretical framework of analysis focused on National Innovation Systems. Section two describes the methodology used for the study. Section three shows the results of the clusters and some of the implications of these.

Section four shows the main efforts of the countries with the greatest potential (Argentina, Brazil and Mexico) in the region to move towards a KBB. Finally, the conclusions are presented.

3.- National Innovation Systems as a theoretical framework of reference

In order to make a transition from the current production system based largely on non-renewable energy sources, as well as unsustainable inputs and processes, incremental innovations alone will not be enough. More radical technological innovations are crucial for a successful transition to a more sustainable system such as the KBB. These innovations need to be applicable in different sectors such as the field, health, energy, etc. and desired by industry, end users, policy makers and stakeholders.

Due to its complexity, applied research leading to these innovations should be organized in a network of different disciplines and agents. Therefore, researchers and developers of biotechnology (in addition to science for purposes and complementary to it) must take into account both the techno-scientific aspects as well as socio-economic aspects such as social norms, legislation, supply chain formation, Logistical challenges, cost efficiency, end-user adoption and market-building. However, classical models of innovation often focus heavily on scientific and technological aspects, only briefly examining socio-economic aspects at the end of the research process. This often results in a multitude of undisclosed barriers that prevent the adoption of innovations by the end user

The connection between the concept of NIS and KBB has been approached by authors such as Roberto Eposti (2012). Where it proposes a system of knowledge and innovation at regional level (EU) for KBB. Where the actors and institutions involved in the system would adapt to the new context of bioeconomy and how policies will accompany and condition this transition. Its approach is based on a system aimed at overcoming sectorial frontiers, improving innovation in the agricultural sector, recognizing the heterogeneity of the various actors involved and adapting EU research, innovation, sustainability and development policies to emerging structures of the KBB. This proposal raises important challenges such as transdisciplinarity, innovation, governance and policy convergence for the transition to KBB and describes a still largely incomplete and country-specific process (Eposti, 2012). Therefore in this paper we will try to evaluate the fundamentals of such a concept through a comparative analysis of the underlying NISs on a broad empirical basis.

Given this necessary environment for the KBB which is complex, multidisciplinary and dynamic, innovation is increasingly addressed from a systems perspective. The system approach asserts that innovation is a multi-stakeholder collective activity that is influenced by the institutional framework and related incentive structures, including market and government policies.

The National Innovation Systems[1] approach illustrates the structure and processes that arise from coevolution and the interdependence of technologies, industries and institutions in an economy (Lundvall, 1992).

[1] Christopher Freeman introduced this concept to explain that the competitiveness of countries is given by many factors other than wages and rates of change since for him, all nations have a "structural competitiveness", which is based on factors such as Institutions, technology and human resources (Freeman 2002)

The NIS approach is based on a basic assumption that the innovation process depends not only on the activities carried out by the companies, but also on the environment that surrounds them, where the institutions that directly promote the creation, acquisition, use and dissemination of new knowledge (to support innovative actors) and are integrated into a specific socio-economic system (Lundvall, 1992, Freeman 2002). Within this system, political and cultural influences as well as economic policies help to determine the scale, direction and relative success of innovation" (Freeman, 2002: 194).

The theoretical and empirical studies of the NIS have helped to describe differences between the various NIS according to the different agents, institutions and frameworks that integrate them and also to discover comparative international similarities in the structure and performance of innovation. This can have an impact in making the mutual learning processes more efficient, for policy planning and development strategies (Urmetzer & Pyka, 2014).

If the countries are to be studied through the NIS in order to know their current state of capacity to move towards a KBB, it must be considered in a transversal way, since a mere analysis of a specific productive sector (eg industrial or the agricultural sector) or simply by measuring its knowledge and innovation capacity in biotechnology or related sciences at the KBB or by identifying public policies that promote the development of the bioeconomy, would not allow conclusions to be drawn about the state of the KBB in one country; However, the total revision of a country's NIS and some other macroeconomic, environmental and development variables can provide clues to identify the current specific characteristics that each country has for a

development towards the KBB.

4.- Empirical Approach

Factors that could (or should) determine a country's ability to transit or adopt a KBB are unknown and highly complex. The plurality and heterogeneity of specific conditions in political, socioeconomic, historical, geographical, scientific and technological, among others; (Including from the same region), in addition to a wide range of "desirable" conditions for an appropriately functioning KBB, make it difficult to have a homogeneous basis for studying transition and development to KBB. Nevretheless, Urmetzer & Pyka, (2014) make a first approximation for a baseline of indicators for monitoring innovation towards the bioeconomy, using those proposed by the OECD to monitor green growth, as well as the objectives defined in the European Bioeconomy Strategy (EC, 2013), these authors suggest six categories of data for the empirical evaluation and for the possibility of introducing the KBB.

In Table 1 the six analytical categories are presented.

Table 1. Categories of analysis and indicators for the cluster model

Category	Description	Indicator	Year/Source
Environmental and resource productivity	Indicates the ability of an economy to minimize consumption of non-renewable resources per unit of output	CO_2 emissions (metric tons per capita)	2015 World Bank
		CO_2 intensity (kg per kg oil equivalent energy use)	2015 World Bank
		Energy use (kg of oil equivalent) per $1,000 GDP	2015 World Bank
		Share of renewable energy in gross final energy consumption (%)	2015 World Bank
		Waste generation (kg/capita)	2015 World Bank
		Recycling rate of municipal waste	2015 World Bank
Scientific, applied and public knowledge	Measures the potential of a country to meet future challenges in the field of bioeconomy with the help of education at different levels	Human Resources in Science and Technology (% of active population)	2015 World Bank
		Researchers FTE (per million inhabitants)	2015 UNESCO
		Scientific and technical journal articles (per thousand capita)	2015 World Bank
		Population with tertiary education attainment (%)	2015 World Bank
		Population with at least secondary education attainment (%)	2015 World Bank
		Total public expenditure on education, all levels (% of GDP)	2015 World Bank
Policy responses and bio-economic opportunities:	Indicate the potential of a nation and willingness to innovate and proceed in terms of technology and institutional	Global Innovation Index	2015 Global Innovaton Index
		Number of biotechnology patents	2015 USPTO
		Total R&D expenditures	2015 World Bank
		Years since publication of bioeconomy strategy	
		Years of participation in selected International Environmental Agreements	
Natural asset base	Measures an economy's ability to manage the quantity of its natural assets	Renewable internal freshwater resources (m3 per inhabitant)	2015 World Bank
		Forest total growing stock (m3 per inhabitant)	2015 FAO

		Share of agricultural land cover (% of total land area	2015 FAO
		Porcentaje de cobertura de la tierra forestal (% de la superficie total)	2015 FAO
		Áreas terrestres y marinas protegidas (% de la superficie territorial total)	2015 FAO
		Terrestrial and marine protected areas (% of total territorial area)	2015 FAO
		Non-renewable natural resources (oil, gas, coal, mineral) rents (% of GDP)	2015 World Bank
The environmental dimension of quality of life	Measures social welfare in terms of access to an unaltered environment (including clean air, intact nature, among others)	Population exposed to particulate matter above WHO thresholds (%)	2015 Environmental Performance Index
		Population with access to improved drinking water (%)	2015 World Bank
		Forest and other wooded land per capita (ha/inhabitant)	2015 FAO
Socio-economic structure	Indicates the socio-economic context in which the different economies operate	GDP per capita in PPS	2015 World Bank
		GINI coefficient (0-100)	2015 World Bank
		Urban population (%)	2015 World Bank
		Employment rate (% of age 20-64)	2015 World Bank
		Value added from agricultural sector (% of GDP)	2015 World Bank
		Share of total organic crop area (% of total agricultural area)	2015 FAO

Source: Elaboration based on (Urmetzer & Pyka, 2014)

For this work, we have considered these categories as the basis for an analysis of the Latin American countries and to determine the current state of NIS in Latin America and the real scope for adopting the KBB.

In order to examine the disposition of the nineteen countries of the Latin American region, indicators are used for each of the aforementioned categories, which correspond to a total of 32 variables.

5.-METHODOLOGY

Cluster analysis is a multivariate statistical technique used to group objects (nineteen Latin American countries in this document), based solely on the characteristics that have (found in the data describing the objects). The objective is that objects within a cluster are similar (or related) to each other and differ from (or are not related to) the objects of other groups or clusters (Cuadras, 2007).

In this work, the classification or formation of clusters, arises from the specific national values for each one of the 32 variables[2] identified to characterize the NIS with respect to their current capacity to initiate a transition towards a KBB.

What is sought in the cluster analysis is to know to what extent the available variables determine the formation of these groups. The objective is to obtain clusters (groups) of countries, having a marked exploratory character (Carrion, 1984).

The analysis will consist of a classification algorithm that will allow us to obtain one or several partitions, according to the established criteria (Cuadras, 2007). The best known criterion (and that will be used in this work) is Euclidean distance. They are usually calculated from raw data, not from standardized data.

The use of the cluster analysis also requires determining the similarities (or otherwise) between the groups. The distance between clusters can be defined as the distance between the two objects nearest or farthest in the clusters. The first case is known as the nearest neighbor clustering and the second, farthest neighbor clustering (Kaufman & Rousseeuw, 2009). As in this case it is sought that the countries of each cluster are as heterogeneous as possible with those of another cluster will use the second method.

6.- RESULTS

The comparative assessment of different NIS is not simple and should be carried out with care. Urmetzer and Pyka (2014) argue that it should not focus specifically on comparing quantitative data, but rather on the efficiency of NIS to achieve the objective in question (to move to the

[2] The original model of Urmetzer & Pyka (2014) consisted of 47 variables for the six categories mentioned, but given the availability of information for the Latin American countries for our study we used 32 of the variables whose data come from the same sources of the original study or similar information from different sources.

KBB). Therefore, comparisons of the quantitative type will be limited to structurally similar countries (belonging to the same cluster) and to differences with respect to indicators that explicitly describe the efficiency of an NIS to transit or adopt a KBB (eg , Energy use (kg of oil equivalent) for $ 1,000 GDP).

The routes towards a KBB that is based on the production and diffusion of new knowledge on renewable biological resources and their potential to be transformed in a sustainable manner in food, forage, bioproducts and bioenergy with the aim of being sustainable in the production and consumption as well As leaving aside the total dependence on fossil resources would be expected to be multiple and difficult to measure and compare.

Clusters resulting from the global analysis of the six categories (32 variables) are presented in different shades on map 1 and the groups are shown in Table 1

Map 1. Distribution of Clusters in the region

Country	Cluster	Country	Cluster
1:Argentina	1	7:Cuba	3
3:Brazil	1	9:El Salvador	3
12:México	1	10:Guatemala	3
2:Bolivia	2	11:Honduras	3
4:Chile	2	15:Paraguay	3
5:Colombia	2	16:Perú	3
6:Costa Rica	2	17:Dominican Republic	3
8:Ecuador	2	13:Nicaragua	4
18:Uruguay	2	14:Panamá	4
		19:Venzuela	4

Source: Prepared based on the results of the analysis.

In the calculation of the variables throughout the region in a global cluster analysis, four groups of countries with similar structures are identified. Argentina, Brazil, and Mexico are countries that can be called rich, with a strong focus on education (higher levels of tertiary education) and human resources training for R & D (full-time researchers and Scientific productivity) that includes a strong knowledge base in biotechnology. They are among the most innovative countries in the region and are based on a large number of natural assets (mainly Mexico and Brazil). Although the members of this group have low energy productivity and high levels of pollution due to their industrial activities, these are the countries most likely to move from the current production model to the KBB. In addition, they present the necessary policy and strategy features to facilitate the adoption of processes and technologies that help to reduce national environmental problems and modernize infrastructure, thereby enabling them to acquire sufficient capabilities to compete in the global market.

The countries that make up the second cluster are Bolivia, Chile, Colombia, Costa Rica, Ecuador and Uruguay. These have medium income levels (except Bolivia), with a solid base of knowledge (although limited in biotechnology) and human resources, But they have a low proportion of jobs in science and technology, therefore they show limited capacity for innovation and R & D expenditure (mainly Bolivia). Its natural assets are scarcer than in the case of cluster one (particularly Uruguay), but the environmental quality of life is above average. A high proportion of the surface of these countries is used in agriculture and the forest. The primary sector (including forestry, hunting and fishing) contributes substantially to total national value added (VA). The countries belonging to this cluster may not have the capacity to build competencies (technological, social and political) in the field of these technologies and their diffusion. However, they show the general some conditions of innovation and an acceptable capacity to absorb new technologies.

The members of the third cluster (Cuba, El Salvador, Guatemala, Honduras, Paraguay, Peru and Dominican Republic) are middle-low income countries with larger agricultural sectors and a primary sector (including forestry, hunting and fishing) It contributes substantially to the total GDP, in addition the income of natural resources, both renewable and non-renewable, are very high (mainly the second). In addition, these countries have little innovation activity in biotechnology and a small proportion of employment in science and technology (Cuba is the exception in both cases). The governments of the nations of this cluster have invested less in education and training of qualified human resources (mainly the Central American countries), and the environment is heavily contaminated. However, because of the relatively low per capita income ratio and the correlation of their overall economic activities, CO2 emissions per capita are lower than those of clusters 1 and 2. This group of countries would have problems in moving to the Bio-economy, mainly due to the lack of human resources (except Cuba) and scientific and technological infrastructure, that could mean that the countries that integrate this cluster, maintain a high dependence of on technology in many of the necessary areas of the KBB, in addition to the high participation in the economies Of the agricultural sector where little value is added and the use of GMOs is very limited. So the overall picture reflects a "classic" dependence on traditional industrial countries as providers of technology

Finally, cluster number four, (Nicaragua, Panama and Venezuela), presents low incomes with very little activity of innovation and formation of human resources in science and technology and practically null in biotechnology; In addition, these countries are highly dependent on their natural resources (mainly Venezuela) and do not have policies, plans or programs to create minimum conditions for innovation and an acceptable capacity to absorb new technologies, all of which hinders the transition to KBB.

The concepts of the indicators used have been derived from the experience in OECD countries for goods with a higher than average technological content, so that a more focused study in the local context (with specific variables of the region) could strengthen the analysis.

The KBB can offer possibilities for productive innovation, economic growth and the creation of quality jobs for developing countries such as those in the Latin American region, as well as solving environmental problems. However, given the historical conditions of scientific and technological backwardness and the measures implemented by the majority of governments in the region over the last thirty years, this may not happen in some nations according to the findings of the study made in this document, since Which indicate that most of the countries (clusters three and four) have significantly reduced incentives for development, production and use of renewable or alternatives energies such as biofuels, in addition there is an increase (in all clusters) of concessions or privatizations for the exploitation of protected public goods (such as forests, aquifers, mines, natural reserves, etc.). This makes it difficult to comply with KBB's environmental objectives.

Therefore, it is possible to think that an approach such as the KBB in the region is already born limited, since only three countries of the nineteen analyzed - Argentina, Brazil and Colombia - have a strategy on the KBB, but these strategies have been limited by compliance with the austerity policies adopted after the financial crisis of 2008. That is why the transition through KBB goes beyond, demanding substantially different efforts from those carried out in most countries, such as higher R & D expenditure and the training of highly qualified human resources (postgraduate courses) focused on sustainability areas (new materials, alternative energies, clean process, among others), in addition to avoiding energy dependence.

Despite these limitations, Latin American countries have much to gain from the comprehensive development of environmental sectors and the innovation, investment and training plans that are necessary to make the region a reference within the KBB approach at the global level.

7.- MAIN EFFORTS AT KBB IN ARGENTINA, BRAZIL AND MEXICO

7.1.- Argentina

In the case of Argentina, there are approximately 120 companies dedicated to the production of biotechnology that focused on different productive fields, among which stand out: seed production, livestock breeding and reproduction, assisted human reproduction, as well as medicines, treatments and other inputs Related to human health. Given the productive structure of Argentina, there is a trend and direction of most large and medium-sized companies to the use of biotechnologies towards the agricultural-livestock sector. Foreign multinational companies are the predominant agents in the agricultural sector (seeds), which produce more than 50% of the country's total (Anlló & Fuchs, 2012).

7.1.1.- Production levels

In the last forty years, soybeans has had an unprecedented evolution in Argentina. Since the early 1970s, the area sown has grown steadily. At that time, only 37,700 hectares were planted with soybeans. In the mid-1990s (when transgenic soybeans were first introduced), more than 6,000,000 hectares were planted, and in 2010, 20,000,000 hectares were harvested. Initially, the increase in production and yields was the result of the introduction of technological packages (especially in terms of new varieties of seeds and the use of agrochemicals) introduced by agro production multinationals, driven by the dynamism of the oil industry vegetable (Pengue, 2001; Anlló & Fuchs, 2012).

Argentina has become the main exporter of soybeans, with sales representing 20% of the national total in 2014. Exports of soybean meal reached 13,088 ton (36% of world exports) and 2.928 million soybean oil (38.5% worldwide) (FAO, 2016).

7.1.2.- Technological development

Although Argentina has not developed technology to produce its own genetically modified seeds, if it has made efforts in biotechnology to ecointensify and diversify its production, the number of academic projects related to biotechnologies has increased. In 2010, Argentina had more than

5,000 researchers working on more than 1,300 research projects related to the use of microorganisms to improve production with good agricultural practices, bioinoculants, bioremediation, the use of microorganisms for the application of biofertilizers in agriculture, Combined use of beneficial microorganisms and bioactive products as an alternative to the use of artificial fertilizers and chemicals, use of antagonistic microorganisms in the control of post-harvest diseases, among other uses of soybean and oleaginous varieties (Stubrin, 2012).

7.2.- Brazil

Brazil, is the country of the region that has based its development of bioeconomy mainly in its biotechnology sector. It is estimated the presence of 237 companies in the same. The private biotechnology sector is concentrated in the southeastern region of Brazil, especially in the states of São Paulo and Minas Gerais. Although the Brazilian biotechnology sector is diversified in companies with research and the agricultural sector, health and various industrial applications, it has made major advances in the energy sector, mainly in biodiesel (Anlló & Fuchs, 2012).

7.2.1.- Production levels

The production of biodiesel in Brazil is in a stage of growth, although at the beginning of a transition to production on a commercial scale, this process began in 2004 from its inclusion in law in the Brazilian energy matrix.

Brazil has important advantages for the production of biofuels (particularly biodiesel). Highlights in particular, the large availability of raw materials and its huge potential for agricultural expansion supplies future demand for biodiesel and other industries such as vegetable oil. It is also important the experience accumulated in the production and its use of ethanol. So far, the country has a production capacity of more than 57 million liters of biodiesel per year, and different biomass sources are used for its production, such as: fatty residues from the refining of palm oil, sunflower, etc. (Rodrigues & Accarini, 2007).

7.2.2.- Technological development

The Brazilian Government uses the Brazilian Biodiesel Technology Network (BBTN) as a source of technological development for the National Biodiesel Production Program (NBPP) (SAGPyA & IICA, 2006). The objectives of this network are:

- The consolidation of a system of articulation of the various actors involved in the research, development and production of biodiesel, allowing the convergence of efforts and optimization of public investments.

- The constant research and technological development carried out in the field of associations between R & D institutions and the productive sector. As well as the identification and elimination of technological bottlenecks for the development of specific local technologies.

7.3.- México

Mexico has identified 375 companies operating in biotechnology, only a few have as their core business to it, while others only include in their productive chains or services, supplies, systems, processes or related applications biotechnology. However, these companies form a broad and varied base of the demand for innovation, adaptation of technology and knowledge in biotechnology. Most of them correspond to the area of pharmaceutical biotechnology, followed by biofuels and new materials (Anlló & Fuchs, 2012).

However, unlike Argentina or Brazil, there is not yet a national strategy aimed at developing or boosting a particular sector for the use of biotechnology, there are notable efforts (but not massive production as in the Brazilian case), especially in the biofuels sector, mainly in biodiesel and bioethanol. In 2008, the Law on the Promotion and Development of Bioenergy (LPDB) was approved, which considers the production of biofuels, such as ethanol, as a strategic priority, through the use of jatropha, manure and oil palm to produce biodiesel (Sacramento, Romero, Cortés, Pech, & Blanco, 2010).

In 2012 there were eighteen projects registered for the production of bioenergetics with an estimated production of 20 million liters of fuels from different biomass sources (Becerra, 2013).

In terms of human capital, more than 3,000 researchers work in Mexico in the areas of biotechnology and applied biosciences, approximately 200 postgraduate programs and basic and applied research in addition to the training of teachers and doctors (Becerra, 2013). But in the absence of a specific public policy that drives, efforts are dispersed and minimize plausible results.

CONCLUSIONS

The objective of this work was to analyze the characteristics of the national innovation systems (NIS) to allow the transition to a KBB based on the knowledge of nineteen countries in Latin America. To achieve this objective, a multivariate hierarchical cluster analysis was performed to detect similarities and differences in six specific NIS areas among the countries of the region. The similarities are of particular interest as there are similar patterns of NIS that allow a better comparison of the results and stimulate the mutual learning of the experience. The differences also point to the dependence of geographical, historical, structural, political and cultural conditions, which hinder the transition to KBB.

Due to the great contrasts that exist between the countries of the Latin American region, there is a clear need for supranational policy (This policy should consider the heterogeneity of the countries in the region in the different areas such as the levels of economic and social development, the different degrees of scientific and technological progress, as well as the environment and quantity and types of biodiversity) planning to avoid that most of the nation's focus on the production of biomass and focus on research through the creation of specialized R & D centers in the least developed countries, thus avoiding a dependence on knowledge produced abroad. This would lead to technological and economic consolidation between more traditional and agricultural-oriented economies and the independence of highly innovative knowledge-based economies.

The results of the cluster can help countries in two ways, in the short term, it will be beneficial for the economies to improve individual areas using as reference the individual indicators reached by other nations within the same cluster.

Countries like Cuba, El Salvador, Guatemala, Honduras, Paraguay, Peru, Dominican Republic Nicaragua, Panama and Venezuela (Clusters number 3 and 4), for example, should strive to adopt the KBB creating incentives (as does Brazil for example) that the industry make more efforts in the development of renewable energies or examining the experiences of Argentina that although it has a focus towards the primary sector has been losing dependence on the transnational companies and has developed its own scientific and technological advances to create GMOs for soy and wheat. In the longer term, however, it will not be sufficient for national policies to be geared to structurally similar economies (such as the cluster 2 cases with those of number 1), but in the longer term they should aim at qualitative and structural change (Through current clusters) towards the three main objectives of KBB: independence of fossil resources, sustainable production and conversion of biological resources and effective production and dissemination of knowledge. This change will not only be achieved through the promotion of technological innovations in the different sectors of the KBB but it must be integrated into NIS social practices.

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