Inferences about socio-economic development in Latin America through the quality of its research

Inferencias sobre el desarrollo socioeconómico en América Latina a través de la calidad de sus investigaciones

BOZA VALLE, Jhon Alejandro[1]
MENDOZA VARGAS, Emma Yolanda[2]
VEGA DE LA CRUZ, Leudis Orlando[3]

Abstract
The objective of this article is to explain the socio-economic development of Latin American nations through the quality of their research, for which statistical inferences were made with multivariate analysis as a research method. The main results are the strong relationship of socio-economic development with the publications ranking in the mainstream databases; dependence on this ranking is strengthened by scientific production and citation rate. In this sense, Brazil, Mexico, Chile and Argentina are leaders in this regard, in order to have a reference for the rest of the Latin American countries, as a strategy to increase their socio-economic development.
key words: socio-economic management model, research quality, dependency techniques, multiple regression, discriminant analysis

Resumen
El objetivo de este artículo es explicar el desarrollo socioeconómico de las naciones latinoamericanas a través de la calidad de su investigación, para lo cual se hicieron inferencias estadísticas con análisis multivariado como método de investigación. Los principales resultados son la fuerte relación entre el desarrollo socioeconómico y las publicaciones que figuran en las principales bases de datos; la dependencia de esta clasificación se ve fortalecida por la producción científica y la tasa de citas. En este sentido, Brasil, México, Chile y Argentina son líderes en este aspecto, a fin de tener una referencia para el resto de los países latinoamericanos, como una estrategia para aumentar su desarrollo socioeconómico.
Palabras clave: modelo de gestión socioeconómica, calidad de la investigación, técnicas de dependencia, regresión múltiple, análisis discriminante.

1 Bachelor's degree in Economics, Universidad Católica de Santiago de Guayaquil University, 1997. Master's degree in Business Management with a concentration in Strategic Management, Universidad Autónoma Regional de los Andes University, 2012. PH.D. in Economics, Universidad de La Habana University, 2016. E-mail: jboza@uteq.edu.ec
2 Bachelor's degree in Marketing Engineering, Universidad Técnica Estatal de Quevedo University, 2008. Master's degree in Business Management with a concentration in Strategic Management, Universidad Autónoma Regional de los Andes University, 2013. E-mail: emendoza@uteq.edu.ec
3 Industrial Engineer (2014). Master in Applied Mathematics and Computer Science for Administration at the University of Holguín (2017). Assistant Professor in the Faculty of Industrial Engineering and Tourism. E-mail: leovega@uho.edu.cu

1. Introduction

The development of the international market for some decades, evidences lacks of consistent methodologies and of appropriate ideas to offer scientific solutions to the modern administration of the organizations, are demanded then, of investigations to improve their products and services, where the university has a role protagonist, to be located between companies, researchers, teachers and students. These professional training entities are in an extraordinary strategic position. In a way, academics take over the knowledge learned in master's and doctorate courses, where research is vital to update knowledge, which is sometimes obsolete and does not take into account the development of the business environment.

In September 2015, the United Nations General Assembly established a transformative vision towards the economic, social and environmental sustainability of the 193 Member States that signed it and will be the reference guide for the institution works in pursuit of this vision for the next 15 years. This new roadmap presents a historic opportunity for Latin America and the Caribbean, since it includes high priority issues for the region, such as the reduction of inequality in all its dimensions, inclusive economic growth with decent work for all, sustainable cities and climate change, among others. Aspect that is closely related to scientific research.

The idea that is defended is to apply the scientific spirit in the administration field and encourage the change of current methods. This becomes important in Latin America where the point is weak, the reduction of its exchange vision derived from its competitive strategy, evidencing a need for improvement to achieve jumping to an "economy driven by innovation", in which some Latin American productive sectors become world leaders. Several countries within this continent converge on the need for scientific innovation for a leading development in Latin America and worldwide. For this reason, among others, it is an objective of the Socioeconomic Model that these countries to increase business competitiveness, from the administration through international scientific research. This article intends to make statistical inferences about the level of socioeconomic development in the Latin American countries that are referents to establish strategic actions of these communities. For this, a bibliometric study was carried out in the mainstream databases and through multivariate analysis inferences were made about the Latin American socioeconomic development and thus promote the Cuban one.

1.1. Theoretical framework

In 2015 the General Assembly of the United Nations, provides an agenda with a transformative vision towards economic, social and environmental sustainability. "The knowledge of the 17 Sustainable Development Goals (SDGs) associated with this Agenda helps to evaluate the starting point of the countries of the region and to analyze and formulate the means to achieve this new vision of sustainable development, reflected in the 2030 Agenda. The SDGs are also a planning tool for countries, both at the national and local levels. Thanks to their long-term vision, they will constitute support for each country on its path towards sustainable, inclusive development in harmony with the environment, through public policies and budgeting, monitoring and evaluation instruments." As this agenda is proactive, it requires the participation of all society sectors and the State for its implementation.

Therefore, the governments representatives, civil society, academia and the private sector are invited to take ownership of this ambitious agenda, to debate it and to use it as a tool for the creation of inclusive and fair societies, at the today people service and future generations, an aspect that is closely related to the Socioeconomic Management Model. This model in Latin America it has been characterized by a scarce role of

international markets, both in labor and financial goods. Consequently, the price system transmits very limited information for the resource allocation and decision making process (Hidalgo de los Santos, 2016, del Castillo Sánchez, 2016). Among the distinctive aspects of the economic model updating is the need to create an adequate institutional framework in the process of implementing the transformations that in the economic order must be made, by first establishing the system of legal norms, taking into account that the law must give the law. In this regard the Ecuadorian President Rafael Correa has stressed that "it can be considered that the first and main economic policy in any society is to build an adequate institutional framework, clear and predictable that allows individuals and the social group to make the most correct economic decisions." (Correa, 2014, p.135).

Among its objectives, the eighth focuses on "promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all". This requires achieving higher levels of economic productivity through diversification, technological modernization and innovation, among other things focusing attention on sectors with greater added value and intensive use of labor. This demonstrates the role of the relationship between the elements of Innovation, Technology and Manpower for an economic and sustainable social development from the nation of each country whose impact affects Latin America and the world.

As a solution to achieve this, development-oriented policies must be promoted that support productive activities, entrepreneurship, creativity and innovation, where universities play a key role in being the bridge of management before these complex activities. These activities materialize in scientific research, which, like a process, transforms the needs of the environment through innovation in value. Its image is reflected in the publications that are articles that reflect current events about research and development about a specific scientific field.

Currently, journals continue to fulfill their purpose of creation and with the expansion of technologies can be found in different formats and at different levels of access, the issue is not to miss the real reason why scientific publications are the most used method and represented by the scientific community. It is essential, then, the construction and maintenance of tools that allow the evaluation of scientific publications, to influence the quality and facilitate access to a type of impact information since the dynamic flow of experience exchange is what ensures the scientific advance of the countries, for this, the editorial board participation is always requested in which different experts in the matter of international and national scope intervene, that guarantee the quality of the publication in Latin America and the Caribbean.

In the nascent economy, the promotion of research and the development of science (Vernal, 2015, Feenstra, 2013, Brandão, 2014) emerges as a priority objective. To achieve this goal is essential to know, measure, evaluate research. Figure 1 shows the investigative process developed by modern nations, as indicators of impact are grouped into indicators of production, visibility, impact, collaboration and relationships. The indicators of production and impact are highlighted by their importance in the management of scientific knowledge in mainstream journals.

Figure 1
Scientific publication process
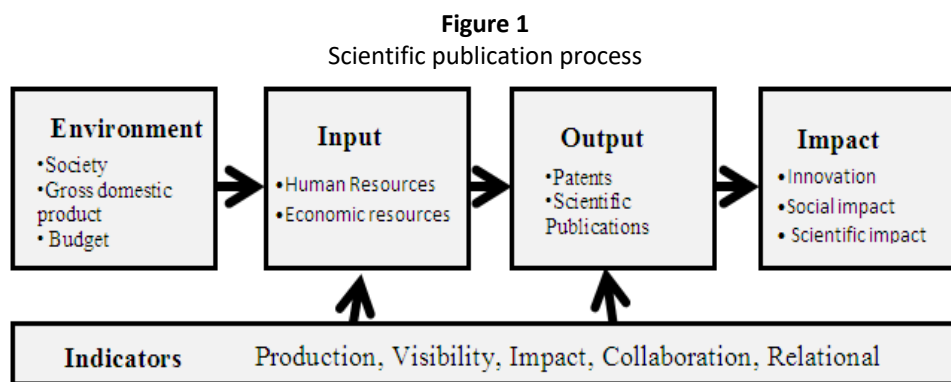
Source: self made

The indicators of production or activity are based on the enumeration and quantification of the documents that are generated. The elementary agents are the researchers, but it is more frequent to calculate production indicators referring to aggregates such as institutions, regions, countries or disciplines (Cejas, 2011) within these the number of documents stand out. The indicators of impact, visibility or quality are the most controversial and questionable in the bibliometric field. They refer to the final value, influence or repercussion of the documents in the rest of the publications (Miró & Burbano, 2013). They are associated with the addresses that reach the bibliographic citations and are generally linked to the impact factor and citation index. They are partial indicators of the originality, clarity, importance and influence of the publications, although their final result is conditioned by the scientific variable production or aggregate that is being evaluated. In this group, the H Index, Self-citation Rate and Appointments by documents stand out.

The H index of Hirsch is an indicator that allows to evaluate the scientific production of a researcher. It was proposed by Jorge Hirsch, of the University of California, in the year 2005. It allows to simultaneously measure the quality (based on the number of citations received) and the quantity of the scientific production and it is very useful to detect the most outstanding research personnel within of an area of knowledge. It gives a lot of importance to the number of publications by the author, thus assessing a prolonged scientific effort throughout an academic life. The citation rates measure the impact factor or citation by documents (Díaz Rojas, 2013).

2. Methodology

It is accepted that statistics are intended to contribute to the increase of understanding, to promote human benefit and improve the quality of life and well-being by means of the advancement of the discovery and effective use of knowledge derived from data. Thus, statistics have arrived to occupy a broad stage in the development of science and technology, but also in the most diverse spheres of daily life, including culture and sports. In this perspective we can say that it is a discipline that came to expand and to incorporate itself into the culture in the knowledge and information society.

Within these stands out the multivariate statistics, which through the techniques of dependence investigates the existence or absence of relationships between two groups of variables. In case these groups are classified as dependent and independent variables, the objective of the dependency techniques will be to establish whether the set of independent variables affects the set of dependent variables jointly or individually.

In general, in order to know which technique should be applied, it is necessary to know how the variables that participate in the study are measured. For the purposes of these studies, multiple linear regression and

discriminant analysis techniques will be used. Multiple linear regression is the appropriate technique if in the analysis there is a dependent variable whose value depends on several independent metric or non-metric variables (Baeza Serrato & Vázquez López, 2014, Astorga Gómez, 2014). In various investigations this technique has a fundamental role since its application allows, among other utilities, to observe how independent variables manage to predict the dependent variable or criterion. In other words, from the regression analysis it will be possible to infer about the existence or not of significant relationships between the independent variables and the criterion or response variable, always within the scientific framework established for the research in progress. On the other hand, Discriminant Analysis is used to classify different individuals into alternative groups (or populations) from the values of a variables set on the individuals to be classified. (Platas Acevedo et al, 2013; Fontalvo Herrera, 2014; Fontalvo Herrera, from the Hoz Granadillo & Vergara, 2012). Each individual can belong to a single group. Belonging to one or the other group is introduced into the analysis by means of a categorical variable that takes as many values as there are groups. In the discriminant analysis, this variable plays the role of a dependent variable.

3. Results

The two main databases of bibliographic references, editorials of Web of Science (WOS) and SCOPUS were used as the object of study. The WOS is a database of journal articles. It has a bias in favor of the scientific field of articles produced in Anglo-Saxon countries and in the English language. Moreover, Scopus is a multidisciplinary database that indexes more than 14,000 scientific journals from 4000 publishers, while offering the references cited since 1996. The time horizon used is from 2010- 2015. The study of the main indicators of production and impact of research in forty-eight countries of Latin America. Where it is evidenced the strong relation with the Ranking of the investigative development with the economic -social development, this result of the implantation of the Economic-Social Model in the Latin American nations.

A discriminant analysis was carried out for the classification of the countries according to the level of development as a dependent variable. After determining the level of development of each Latin American country. The Discriminant classification method was applied to assign the priority level of each, obtaining this as a result of the Statistic Program for Social Sciences (SPSS) software for Windows version 20.0 , the summary of table 1:

Table 1
Processing summary for case analysis

Valid: 100%		Excluded: 0%		
Equality tests of group means				
	Lambda de Wilks	F	gl1	gl2	Sig.
Documents	,438	28,903	2	45	,000
Citations per document	,986	,311	2	45	,034
Citations	,348	42,076	2	45	,000
Self-citations	,444	28,219	2	45	,000
H index	,173	107,681	2	45	,000

As shown in the previous table, the Wilks' Lambda values are close to zero, indicating that a part of the total variability is attributable to the differences between the group means, which means that the groups are heterogeneous with each other, On the other hand, the Sig values are less than 5% and consequently there are

differences between the group means, or sea, they are heterogeneous. Table 2 shows the summary of the classifications where the percentage of variance for each discriminant function is reported, the first accumulates 91,9%, while the second the 8 , 1%, although the Wilks λ is significant for both functions, but being more favorable to the first, hence, that the first canonical correlation is also high thus distinguish the criteria have high influence on the leaderboard.

Table 2
Summary of canonical classifications

| E-values			Lambda de Wilks				
Function	Autovalue	% variance	Canonical correlation	Contrast functions	Lambda de Wilks	Chi squared	gl	S.I.G.
1	8,492 a	91.9	946	1 to 2	, 060	123,610	6	, 000
2	749 a	8.1	654	2	572	24,592	2	, 000
a) The first 2 canonical discriminant functions have been used in the analysis..								

In the classification plan of figure 2 we can see the graphic summary of the classifications according to the level of development, taking into account the quality of the research in Latin America, it is observed that all the countries are at a relatively small distance showing similar characteristics socio-economic activities of the Latin American continent. This distance appears smaller in the middle and lower development countries, where Cuba is located, the strategies for these countries will be to shorten the distance with the developed countries through benchmarking strategies and in the future to continue these actions in relation to the developed countries.

Figure 2
Classification plan
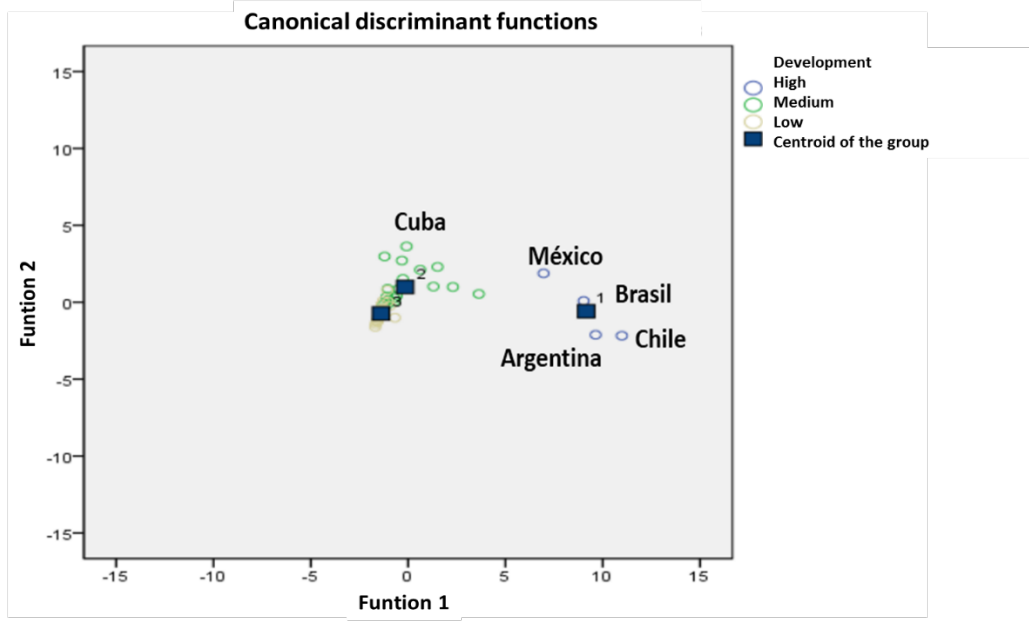
The result of the analysis showed that only four countries have a high level of research development and therefore, economic and social, these are Brazil1, Chile, Argentina and Mexico, on the other hand twenty countries maintain an average development where Cuba is among the leaders of this group and twenty-four countries with low development, predominant group in Latin America. Figure 3 shows a Pareto analysis where 80% of scientific research in this continent corresponds to the research of the four countries classified as high development. On the other hand, Pearson's correlation coefficient with 0.998, offers the strong relationship between the development of research and Latin American socioeconomic development, so this direct relationship provides the information to influence the quality of research for sustainable socioeconomic development.

**Figure 3**
Pareto Analysis for No. of Documents
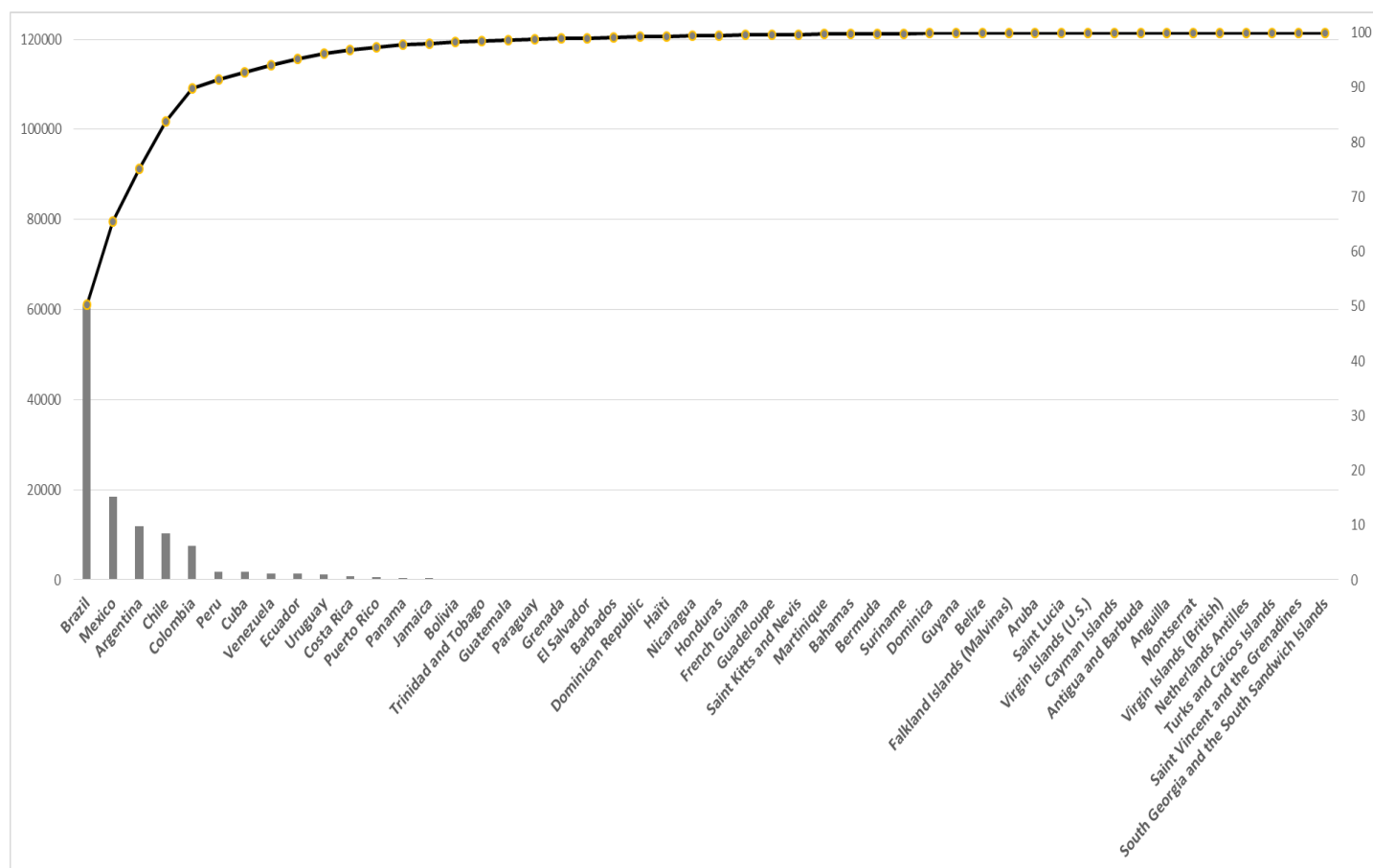
Source: self made

---

[1] Mantiene este nivel al incluir en este análisis el resto de los países de los otros continentes.

Carrying out a centrality analysis whose social network is shown in Figure 4. It is evident that the relationship between Latin American countries according to their strengths and weaknesses in the effectiveness of their research.

Figure 4
Social network of research quality in Latin America
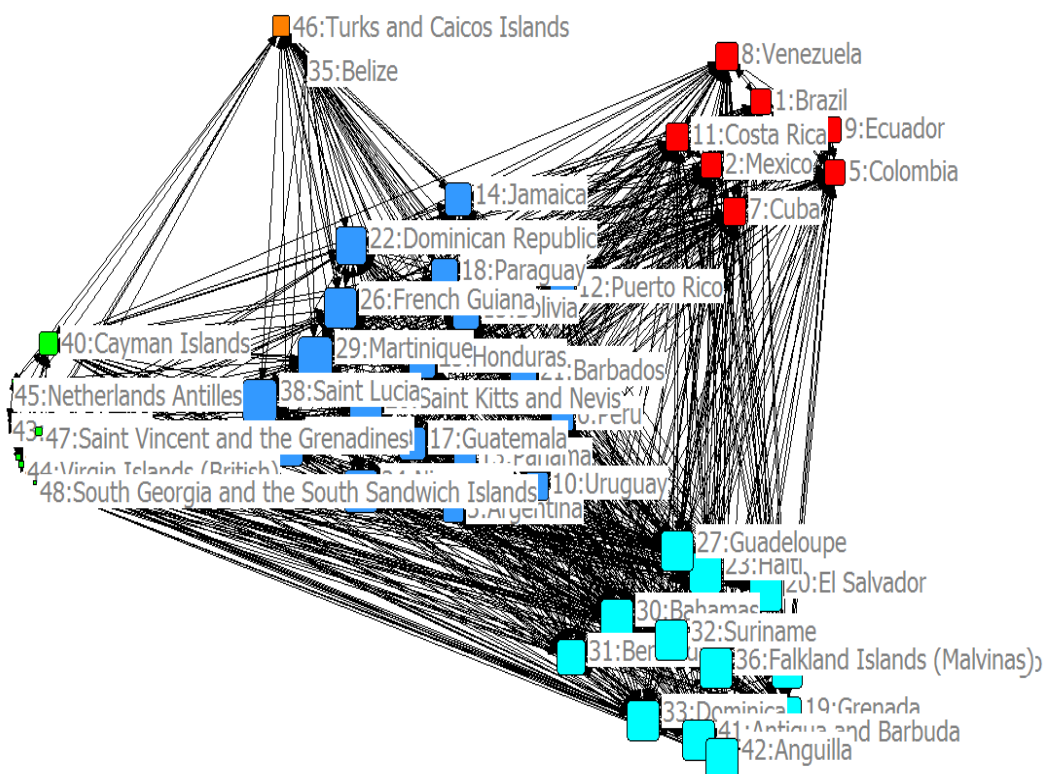
From the previous analysis it is concluded that it maintains a high similarity with countries of high research quality in this continent such as Cuba, Brazil, Mexico, Colombia, Venezuela, Costa Rica, Ecuador according to the number of investigations, self-citations, index H and citations for documents. To establish a strategy, a multiple regression analysis was performed, this is summarized in Table 3, where the main results are exposed to establish a strategy of Rankin increase, as a dependent variable, of the quality of investigations and therefore a greater socio-economic development.

Table 3
Summary of regression analysis

Coefficients [a]				Summary of model [b]		
	Non-standardized coefficients		Typified coefficients	R squared corrected		,779
Model	B	Typ error		Typ error of the estimate		6,399
(Constant)	38,513	1,714	Beta	Tolerances	t	S.I.G.
Documents	-, 001	, 001	-, 572	, 803	22,469	, 000
Citations	, 014	, 003	4,176	, 673	- 596	, 043
Self-citations	-, 027	, 012	-2,528	, 862	4,436	, 000
Citations per document	-, 053	1,134	-, 003	, 972	-2,258	, 027
H index	-, 245	, 023	-1,882	691	-, 047	, 023
ANOVA	Sum of squares	gl	Half quadratic	F		S.I.G.
	11147,368	5	2229,474	54,453		, 000 [a]
	2906,943	71	40,943			
	14054,312	76		Durbin-Watson		1,579

As can be seen, the five variables included in the analysis explain 77.9% of the variance of the dependent variable, since R 2 corrected = 0.779. In addition, the typical waste error is small, indicating a small improvement in the fit. It is observed that the corrected value of R 2 is almost identical to the uncorrected value.

The value of the critical level Sig = 0.000 in the ANOVA indicates that there is a significant linear relationship. We can affirm, therefore, that the hyperplane defined by the regression equation offers a good adjustment to reality. The non-standardized coefficients indicate that, if the rest of the variables remain constant, an increase of one hundred units of documents corresponds to it, on average, a decrease of a Rankin. Observing the Beta coefficients, we see that the variable numbers of documents and citation are the most important. All of them, therefore, contribute significantly to explain what happens with the development Rankin. For the analysis of the assumptions is that since the Durbin-Watson value = 1.579 is between 1.5 and 2.5, we can assume that the residuals are independent, the normal probability graph of Figure 4 shows information that the points are aligned on the diagonal of the graph, which is warning us again of the possible compliance with the assumption of normality. In this context of the regression analysis, the relationship between the dependent variable and each of the independent variables separately, after eliminating the effect of the rest of the independent variables included in the analysis and revealing a linear relationship of these variables with the Ranking variable. Hence the presence of non-collinearity (small tolerances) is the stability of the estimates of the regression coefficients, the independent variables do not have a strong relationship between them.

Figure 4
Normal regression graph
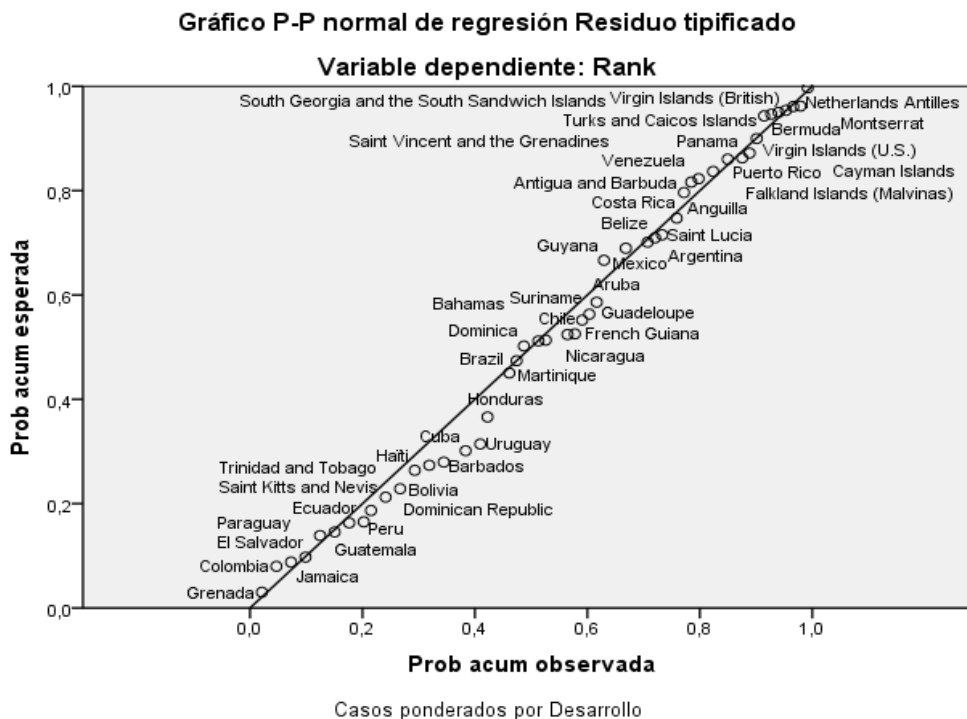
From the previous analysis we can deduce strategies for increasing the development of a Latin American country , we must increase the number of scientific documents, in addition to the number of citations, guide the content of the publications towards the research topics of the high development countries, by On the other hand, they should focus on investment and international relations, accentuating the innovation of their potential actors such as universities and companies in business improvement, enhancing their strengths in increasing innovations in the area of engineering.

4. Conclusions

The dependence techniques in the multivariate analysis constitute relevant tools for the analysis of statistical inferences in socioeconomic variables. The research development maintains a strong and direct relationship with the socioeconomic development of the nations, specifically in Latin America the countries of high research development such as Brazil, Argentina, Mexico and Chile provide 80% of the research in the continent. As a strategy for low and medium development countries, the quality of their research should be directed towards the increase of scientific production and bibliographic citations on investment and business management issues.

Bibliographic references

Astorga Gómez Juan M. (2014). Aplicación de modelos de regresión lineal para determinar las armónicas de tensión y corriente. *Ingeniería Energética*, *35*(3), 234-241. Recuperado en 04 de abril de 2017, de http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1815-59012014000300008&lng=es&tlng=es.

Baeza Serrato, Roberto, & Vázquez López, José Antonio. (2014). Transición de un modelo de regresión lineal múltiple predictivo, a un modelo de regresión no lineal simple explicativo con mejor nivel de predicción: Un enfoque de dinámica de sistemas. *Revista Facultad de Ingeniería Universidad de Antioquia*, (71), 59-71. Retrieved April 04, 2017, from http://www.scielo.org.co/scielo.php?script=sci_arttext&pid=S0120-62302014000200007&lng=en&tlng=es.

Brandão, Angela S. (2014). Mediatización más Allá de las Democracias Maduras: una Propuesta Tridimensional para Medir la Influencia de los Medios en Brasil. *Cuadernos.info*, (34), 153-164. https://dx.doi.org/10.7764/cdi.34.523

Cejas, Claudia. (2011). Indicadores bibliométricos de las revistas biomédicas. *Revista argentina de radiología*, *75*(1), 5-6. Recuperado en 04 de abril de 2017, de http://www.scielo.org.ar/scielo.php?script=sci_arttext&pid=S1852-99922011000100001&lng=es&tlng=es.

CORREA, R. (2014): Ecuador: de Banana Republica la no república. Fondo editorial Casa de las Américas, La Habana.

Del Castillo Sánchez, Luis. (2016). El perfeccionamiento de la gestión de la empresa estatal y sus retos actuales en Cuba. Economía y Desarrollo, 156(1), 142-154. Recuperado en 19 de junio de 2017, de http://scieloprueba.sld.cu/scielo.php?script=sci_arttext&pid=S0252-85842016000100010&lng=es&tlng=es.

Díaz Rojas, Horacio. (2013). Reconocimiento de la productividad científica en Chile. *Ingeniare. Revista chilena de ingeniería*, *21*(2), 170-171. https://dx.doi.org/10.4067/S0718-33052013000200001

Feenstra, Ramón A. (2013). La Monitorización de la Publicidad en la Era Digital: Un Reto para la Ética. *Cuadernos.info*, (32), 47-58. https://dx.doi.org/10.7764/cdi.32.477

Fontalvo Herrera, Tomás José. (2014). Aplicación de análisis discriminante para evaluar la productividad como resultado de la certificación BASC en las empresas de la ciudad de Cartagena. *Contaduría y administración*, *59*(1), 43-62. Recuperado en 04 de abril de 2017, de http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0186-10422014000100003&lng=es&tlng=es.

Fontalvo Herrera, Tomás, de la Hoz Granadillo, Efraín, & Vergara, Juan Carlos. (2012). Aplicación de análisis discriminante para evaluar el mejoramiento de los indicadores financieros en las empresas del sector alimento de Barranquilla-Colombia. *Ingeniare. Revista chilena de ingeniería*, *20*(3), 320-330. https://dx.doi.org/10.4067/S0718-33052012000300006

Hidalgo de los Santos, Vilma. (2016). El modelo económico cubano: reflexiones desde una perspectiva macroeconómica. Economía y Desarrollo, 156(1), 108-130. Recuperado en 19 de junio de 2017, de http://scieloprueba.sld.cu/scielo.php?script=sci_arttext&pid=S0252-85842016000100008&lng=es&tlng=es.

Miró, Ò., & Burbano, P.. (2013). El factor de impacto, el índice h y otros indicadores bibliométricos. *Anales del Sistema Sanitario de Navarra*, *36*(3), 371-377. https://dx.doi.org/10.4321/S1137-66272013000300001

Platas Acevedo, Romana Silvia, Gómez-Peresmitré, Gilda, León Hernández, Rodrigo, Pineda García, Gisela, & Guzmán Saldaña, Rebeca. (2013). Capacidad Discriminante y Clasificación Correcta de la Escala de Factores de riesgo Asociados con Trastornos de la alimentación (EFRATA-II). *Revista mexicana de trastornos alimentarios*, *4*(2), 124-132. Recuperado en 04 de abril de 2017, de

http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S2007-15232013000200006&lng=es&tlng=es.

Vernal, Teresa. (2015). La comunicación científica para el desarrollo cultural y económico: El caso de las potencialidades astronómicas de la Región de Antofagasta en Chile. *Cuadernos.info*, (37), 213-224. https://dx.doi.org/10.7764/cdi.37.691

331