Assessment of Innovation Factors that Impact Competitiveness in the Mexican State Entities through DEA analysis

Evaluación de factores de innovación que impactan en la competitividad estatal de México a través del análisis DEA

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Abstract

This is an applied research that expects to contribute at the estate entity, regional and national level. It aims to contrast the efficiency assessment of the Mexican state entities throughout the understanding of innovative factors and their distance from the efficiency frontier by applying the Data Envelopment Analysis (DEA) analysis, after applying a multivariable correlation and principal component analysis. The relevance of this research lies in the implementation of an analytical instrument to categorize the variables that highlights and those which should improve to increase the national innovation level. The results show the relevance of Baja California and Sonora besides Distrito Federal and Nuevo León in the national indicators and the revelation of Morelos as a relevant state in patent PIB ratio growth of specialized industry and services.

Keywords: Innovation factors, governmental sector, Data Envelopment Analysis (DEA), economic development, Mexican estate entities and national competitiveness.

Classification code: JEL Classification Codes Guide – 0540 Economywide Country Studies: Latin America; Caribbean

Resumen

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Esta es una investigación aplicada que incide en la toma de decisiones hacia entidades a nivel estatal, regional o nacional. Su objetivo es evaluar la eficiencia de las entidades estatales de México a través de la comprensión de los factores de innovación y su distancia de la frontera de eficiencia mediante la aplicación del Análisis Envolvente de Datos (DEA), al aplicar un análisis de componentes principales. La relevancia de esta investigación radica en considerar variables en la aplicación de un instrumento de análisis para categorizar las variables que sobresalen y las que deben mejorar para aumentar el nivel de innovación nacional. Los resultados muestran la relevancia de Baja California y Sonora además de Distrito Federal y Nuevo León en los indicadores nacionales; así como, la revelación de Morelos en crecimiento del PIB en relación de patentes y del PIB en especialización de industria y los servicios.

Palabras clave: Factores de innovación, sector gubernamental, Análisis Envolvente de Datos, desarrollo económico, entidades estales mexicanas, competitividad nacional.

1 Introduction

Innovation is essential to obtain a competitive position (Davis, 2013), either in terms of private organizations or public sector, as the correspondent research, which analyses the Mexican state entities. Unlike innovation emanated by private sector focuses primarily on profitable opportunities for its shareholders, the one at public sector seeks to develop skills and provide better capabilities as well as social relationships and participation from individuals and communities to societies. This article considers innovation as a primordial factor of competitiveness, particularly it is focused on institutional efficiency due to its direct relation with productivity and economic output in order to contribute with the progress of standard of living in society.

This article considers the interrelation of competitiveness into different entities which conform the national territory. It aims to interrelate the theoretical framework such a global innovation index and interrelates it with the national innovation program. The dimensions take into account

were development, science and technology as well as innovation. The previous theoretical framework generates an analysis to innovate the Mexican estate entities.

The study is divided into three sections. The first one considers the theoretical framework of the competitiveness concept at a national glance and the interrelationship between national competitiveness, innovation, efficiency and derived from that analysis a variable selection and its systemic art study. The second section contemplates the Mexican context, taking into account national data based on the variables selected considered by the states that compose the Mexican Republic; most of data are based of the Foro Consultivo Científico y Tecnológico (FCCyT). The methodology of the present search is based on a quantitative methodology based on principal components, data envelopment analysis.

2Theoretical Framework

2.1 National competitiveness concept

According to Porter (1990), the only meaningful concept of competitiveness at the national level is productivity. By contrast, Mayor et al. (2012), consider that "competitiveness is associated with the concept of productivity, in the sense that higher yields of natural resources, labor and capital are a necessary condition, but not sufficient to make that a country, region or county achieve to increase its competitiveness".

According to Chernega & Bocharova (2013), competitiveness of a national economy is the cause, effect and the criterion of the real and potential comparative ability of a national economy

as a whole; thus, its individual components might ensure sustainable growth of national wealth and influence the geo-economic transformation. The Organization for Economic Cooperation and Development (OECD) defines global competitiveness as "the ability of a country to produce products that can successfully compete with the products from other countries on international markets and to continuously increase its population living standards (OECD, 2011).

Competitiveness is defined as the set of factors, policies and institutions that determine the present productivity level of a country, and productivity determines both the welfare level of an economy at a certain moment and its growth potential in the future, as is stated by Tănase (2011), who considers that competitiveness is created at the microeconomic level, but is supported and consolidated at the macroeconomic level. Neslihan & Hüseyin (2012) also sustain that to achieve higher competitiveness a country should improve its competitiveness both at the firm and industrial level.

Along this article, competitiveness is considered in a holistic sense, enclosing not only economic and qualitative benefits such as educational level, health and human capital development but also factors that determine the productivity level to ensure innovation in order to develop useful capabilities to ensure the future generation requirements.

2.2 Interrelationship between national competitiveness and innovation

Adam Smith manifested that free markets provided the greatest degree of innovation since markets provide competition, due to companies under competitive pressure innovate to beat the

competition (Kealey, 2008). Porter established that innovation is a competitiveness factor. For him "innovation, or rather the ability to innovate, underlies effective action (competitiveness) that leads to the well-being of nations" (Porter, 2001, p. 3). A matter of fact is that in the contemporary world this ability is the main source of competitive advantages. Consequently, it increases the role of innovations, which contribute to the competitiveness of economies. For instance, those improving the organizational basic and applied research systems as the financing of innovative projects (Lewandowska, 2013).

2.3 Beyond the efficient innovation

Knowledge bases and organizational capacity are factors that build innovation capabilities and result in the adoption of learning and contribute directly to prosperity, welfare of citizens and society (Bell & Figueredo, 2012). Additionally, crucial investments and appropriate policies in research and development (R & D) generates efficiency and quality in the public distributed expenditure and increases a leading position in a number of fields of knowledge and key technologies (Enache & Dovleac, 2015).

Burgos (2010) and Teece (2010) comprehends the link innovation-development as a natural direction of entities toward improvement; that is, toward the efficiency of institutions; moreover for Atkinson (2013), innovation is related to productivity and can be defined as the economic output per unit of input, where the unit of input can be labor hours (labor productivity) or all production factors including labor, machines and energy (total factor of productivity). Indeed, Hickman (1992), defines international competitiveness as the ability to sustain, in a global

economy an acceptable growth in the real standard of living of the population with an acceptably fair distribution, while efficiently providing employment for substantially all who can and wish to work and doing so without reducing the growth potential in the standards of living of future generations.

Efficiency is an indicator that measures competitiveness in organizations, Augusto et al. (2005) generated methodologies of multi-criteria analysis to improve strategic competitiveness. Lipovatz, Mandaraka & Mourelatos (2000) applied a canonical analysis to correlate the productivity variable with labor productivity, vertical integration and technological innovation as microeconomic variables and the analysis of market structure and the degree of introduced innovations as macroeconomic variables. Meanwhile, Tceplit, Grigoriev & Osipov (2014), developed a methodology that contrasts different models in order to determine the overall index of competitiveness of products and represents the weighted average cost techniques.

The competitiveness analysis is breakdown by the economic theory with the concept of efficiency and the analysis of efficiency at organizations. Thus, the efficiency measurement techniques attempt to assess the behavior of an entity with respect to an optimum value. By comparing economic elements is possible to identify better government and/or business practices.

2.4 Variables selection

According to Chernega & Bocharova (2013), competitiveness strategies of a national economy in most countries demonstrate their incapacity and do not provide expected results. They expose that the countries-leaders based on the ranking of competitiveness has not changed during the twentieth century, and it includes: the USA, Switzerland, Sweden, the Netherlands, Denmark, Canada, Australia, Singapore, Hong Kong and Belgium. Additionally, there exist multiple variables to measure innovation as it is exposed in the following analysis of state of the art that summarizes the literature review on variables related with inputs and outputs stated as determinants of competitiveness and innovation.

Table 1. Inputs variables.

INPUTS	
Tellis, Prabhu, & Chandy (2009)	Labor as skilled force; capital as available financial resources; government policies related with intellectual property and technology development; culture as attitudes and practices shared by members of a collective entity that drives radical innovation and value creation.
Ugur (2013)	Good governance should provide: (i) security of property rights, (ii) enforcement of contracts (iii) resolution of collective action problems, and include: quality of the bureaucracy, control of corruption, investment profile, law, order and government stability.
Damanpour's (1991)	The author´s meta-analysis confirmed 13 factors that influenced the adoption of innovation: specialization, centralization, internal, external communication and technical knowledge resources.
Porter & Stern (2001 p.4)	The institutional and microeconomic environmental play an important role in determining the productivity of investments in innovation.
Atkinson & Messy (2012)	Cooperation, good governance; climate change R&D, biodiversity; electricity and water access; education; physic infrastructure; services, agriculture and mining; legal and public policies for innovation institutional context.
United Nations Conference on Trade and Development. UNCTAD (2012).	Market and economy attractiveness, low-cost labor and skills availability, presence of natural resources, enabling infrastructure, technological learning and collaboration, Foreign Direct Investment (FDI), Capital Goods Importation, export of capacity and share of GDP to assess trends exchange; indicators of R&D; education, cost-quality conditions of manufacturing; efficient oriented manufacturing.
Index, G.I. (2014)	Institutions, human capital and research, infrastructure, market and business sophistication.
Secretaría de Economía (SE). Programa Nacional de Innovación 2006-2012.	According to the National Innovation Program, the innovation ecosystem relates variables in systems of national and international markets, knowledge generation, the same business innovation, innovation funding, human capital and the regulatory framework as well as industrial property rights.

Source: Own creation based in above-mentioned articles (Authors and quotations).

Table 2. Output variables

OUTPUTS	
	Youth job creation; economy on track; increase the enterprises competitiveness in the global market; solve the aging population challenge; secure resources like food and fuel; fight global warming; smart and green transport.
Ghazal & Zulkhibri (2015)	Fertile ground to attract foreign direct investment (FDI) to lead innovation outputs. Increase governance factors in institutions to increase innovation activities in developing economies. Economic freedom indicators to improve innovation outputs.
Thakurta &	Introduction of new or improved goods or services; operational processes; organizational and administrative processes, to

Banerjee (2014)	improve market share, competitiveness, quality of the product/services and cost reduction.
Thakurta & Banerjee (2014)	Patents measurement, R&D intensity and propose; spread of IP protection; increase the innovation value at social level; venture capitalists and mechanisms for funding startups; better cooperation and coordination among academic institutions and industries; increase the specialized education and continuous training.
Petrović Ranñelović and Radukić (2013)	Foreign direct investment (FDI) in the host country may potentially contribute to increasing national competitiveness, and vice versa, higher rankings of national competitiveness can be stimulating effect in attracting greater FDI flows.
Herranz, A. Á., Barraza, J. E., & Legato, A. M., (2009)	FDI only improves economic growth in the long term by modifying two exogenous factors: technology and labor. According to the endogenous model, FDI does impact on economic development in the long term a country indirectly through both capital formation and the development of human resources. The effects of FDI occur through externalities produced, such as technology transfer and spillovers.
Fernández-Rodríguez Labordeta and Giménez (2012)	Technological innovation explained as per capita number of patents, education quality than for the amount of education.
Tellis, G. J., Prabhu, J. C., & Chandy, R. K., (2009)	Additionally, the authors establish the lack of an output innovation analysis such as innovations commercialization or financial rewards. For that reason, they consider that the government should be involvement in the diffusion of innovation through its procurement of innovative outputs in sectors such as defense, health, and education.
United Nations Conference on Trade and Development (UNCTAD). (2012).	Construction of infrastructure, provision of industry goods as well as jobs, and generation of sustainable growth, FDI by SWFs presents a significant opportunity. Patenting, licensing, researchers per million people, infrastructure; as well as collaboration intra - firms, interregional. Guidelines to follow investment in educational technology, support local businesses, institutional linkage to generate supportive environment for innovation; and, collaboration and technology transfer. Value added exportations, employment, wages and salaries, tax revenue.
Global Innovation Index (GII) (2014)	Knowledge and technological products or outputs and creative products.
National Innovation Program. Mexico.	Scientific production, former researchers, patents, enterprise innovation.

Source: Own creation based in above-mentioned articles (Authors and quotations)

2.5 Mexican contextualization

According to the Foro Consultivo Cientifico y Tecnologico (FCCyT), the advancements in the national science, technology and innovation (STI) are extraordinary; however, there are still important opportunity areas and heterogeneities that shall be improved. The Ranking 2013 (Dutrenit Bielous, et al., 2014) results of the STI capacities denote that the five relevant entities in Mexico are: Distrito Federal, Nuevo Leon, Queretaro, Jalisco and Morelos, while the less advanced are Tabasco, Chiapas, Oaxaca, Guerrero and Campeche.

According to the Foro Consultivo Cientifico y Tecnologico (FCCyT) the state entity that highlights in the business infrastructure dimension is Nuevo León, this entity positioned as the

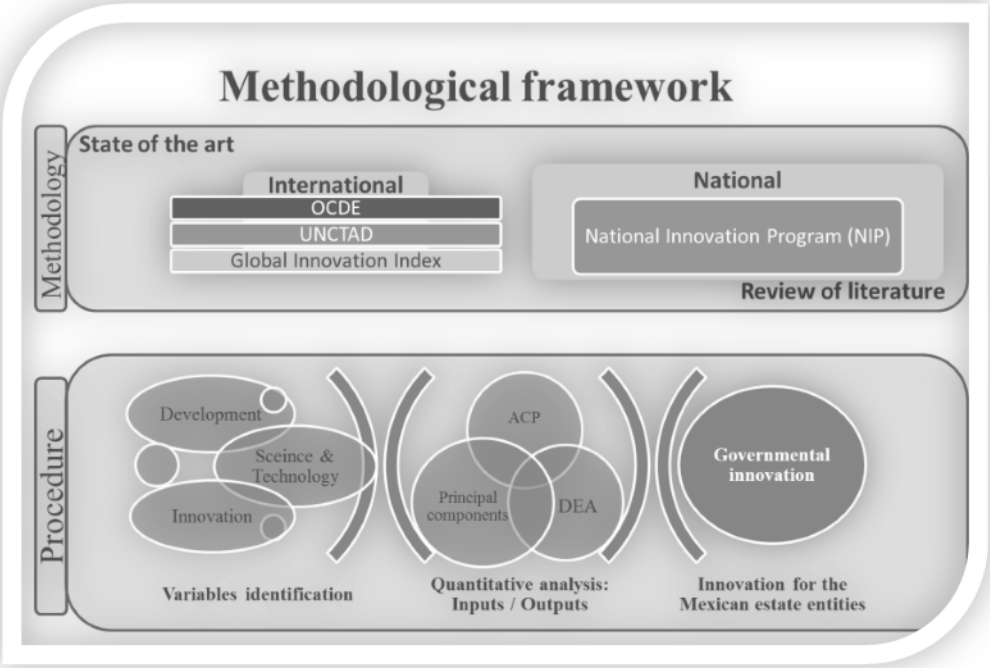
first one due to its PIB of $151,706 (2010); an investment per worker of $9,110 (2010), a population rate with higher education (PEA in Spanish) (2010) of 43% and has the highest PEA with postgraduate, 840.75 of every 100 000 inhabitants. Campeche and Tabasco have a high rate of technological Institutes at SEP for every 100 mil of the PEA (2012), 1.5 y 0.9 respectively. Tamaulipas, Tabasco, Campeche or Colima by its side, are the entity with the best rate in human capital performance. Queretaro, Morelos and Baja California highlights by their distinguish research and researchers. For instance, Morelos has 10 000 SNI researchers of its PEA (11.33). A relevant indicator is the investment in STI, and Queretaro, Nuevo Leon y Chihuahua were the entities that highlighted. Nuevo León, Jalisco and Querétaro are the entities with more inventive activity. Additionally, Nuevo León and Baja California have the highest rate of innovative enterprises, exceeding the numbers of Distrito Federal.

In contrast, the entities with a higher poverty percentage in 2012 were Chiapas 74.7%, Guerrero 69.7% y Puebla 64.5%. Morelos has the less human capital performance. Furthermore, even Campeche is one of the states with more technological institutes; it is one of the three entities with less inventive activity, with Nayarit and Guerrero. In addition Campeche and Guerrero are the entities with fewer rates of innovative enterprises. The FCCyT concludes that the most developed entities possess the higher scientific, technological and innovation capacities.

3. Methodology

In the graph presented below is shown the integral development of the methodology. First there were selected and grouped the variables to be analyzed, derived from the review of the literature

as well as national and international index and programs. The review resulted in a selected group of variables that were examined at the national level in the Mexican context. Then, a quantitative analysis was implemented with the inputs and outputs of the variables selected in the literature review and to identify which were the ones that more contribute to the governmental innovation.



Source: Own elaboration.

Graphic 1. Methodological and quantitative procedure framework.

3.1 Quantitative methods

The quantitative analysis generates certainty and increases stronghold of the selected variables, which are analyzed within the Mexican State Entities. Then, the advantages and justification of using the quantitative techniques are exposed and used in the analyzed information.

It is used the methodology of the Principal Component Analysis (PCA) due to it has been studied to evaluate the national competitiveness and to build the corresponding ranking in regions such as the Eurasian one (Verenikin, & Verenikina (2018); another example using this methodology is the study generated by Jovan & Bradić-Martinović (2014) in the South Eastern Europe (SEE region), used the factor analysis method to reduce the large number of variables and later the Principal Component Analysis (PCA) to generate a correlation matrix to eliminate the variables which cannot be uniquely determined to one single factor. Stevans, et al. (2012) by their side took the IMD World Competitiveness Yearbook (WCY) data basis and divided in 20 sub factors to develop indices of countries competitiveness. Into the study one can observe how they transform the original set of variables into a new one, in that case they used later principal components, however in our study we combine it with another approach, which is explained in the following lines.

Additionally, the approach was combined with the data envelopment analysis (DEA). There exist different studies which employs DEA approach to analyze national competitiveness. Among some research are the one of Afzal (2014), which measure the national innovation system of 20 emerging and developing countries considering their technical efficiency. Lee et al. (2010) which measure the efficiency of the national R&D performance in the sector of hydrogen energy technology development in Korea; Pan et al. (2010) who measure the performance of the national innovation system in Asia and Europe; Xu & Liu (2017) measure the efficiency of education and technology via DEA and analyze the implications on national development of 53 countries in East Asia; as well as Azfal et al. (2019) which study the national innovation system according to the Porter´s Diamond Model in the group of ASEAN-05.

3.1.1 Data Envelopment Analysis (DEA)

DEA analysis represents graphically the "envelopes" faces, defining the efficient and inefficient units. It becomes relevant to know well the distance (actions) that separate the efficient DMUs of those who are not. It sets the guideline for the progress of the entities who wish to achieve the so-called benchmarks or optimal points. The described situation presents an implicit problematic in relation to the "targets" to be achieved less efficient DMUs because common sense explains the inability to compete with benchmarks for which efficiency is too big to find a comparison. Similarly, the DEA analysis could be reconfigured to seek a single-stage process to achieve the nearest efficiency goals and not just radials as proposed by Coelli (1998).

An advantage of DEA is to obtain efficiency in the use of multiple units in its function as inputs or outputs. It also presents some criticism in that does not include influences on the productive process, which creates uncertainty in the final results. That is, one unit can be considered efficient according to the data that have been collected and the relationships that presumably have been included in the study. Drake & Howcroft (1994) indicate that the DEA works more optimally if the number of observations is closer to the double of the inputs and outputs sum and states that in studies with small samples must be added categories.

Since the progress of this technique some still latent problems are recognized to define the most efficient unit (DMU) as an option for the decision maker. Even, more than one author agrees

with the complexity of identifying the optimum DMU. So, the DEA models create from iterations progress in the proposal to elect the efficient DMU (Mendhi and Soroosh, 2009)

3.1.2 Principal Component Analysis (PCA)

In research and case studies it is required to manage and integrate the large possible amount of information. It involves collecting a large number of variables involved; an amount of data of different category and a different amount of collected data interrelated. It implies that there are ample opportunities for variability in a study. Therefore, it is necessary to reduce the number of variables in the theoretical justification for variables with strong correlation which measure the same from different approaches.

The PCA transforms an original set of variables into another set of variables correlated within each other. These new variables, according to the variability of its samples are constructed as linear combinations of the original in order to collect most part of the information. The components are chosen according to the highest possible variance under the following mathematical model:

$$a_j' a_j = \sum_{k=1}^{p} a_{kj}^2 = 1$$

The following components are chosen according to the existent correlation through random variables with less and less variance.

3.1.2.1 Selection of variables with PCA

The study collects information, as mentioned in the state of the art of the variables involved with competitiveness, innovation ecosystem, programs and index guidelines and how efficiency interrelates them. The choice of variables is based on literature review of different contemporary authors as well as international index and national program of innovation in Mexico. Those index and programs are based on the productivity concept and factors such as product optimization and innovation ecosystem. Those variables are 36 and are the following ones:

Table 3. Independent Variables

No.	Variable	No.	Variable	No.	Variable	No.	Variable	No.	Variable	No.	Variable
1	Public Security Perception Index	7	Corruption perception in governmental acts.	13	Superior educational level absorption	19	Economically active working population	25	Flow of foreign visitors	31	People of working age
2	Enforcing contracts	8	Federal contribution	14	Academic performance	20	Paved road index	26	Researchers number	32	Economically active population
3	Electricity consumption	9	State Budget information index	15	Foreign student in bachelor level	21	Air Traffic	27	Companies, scientific and technological institutions	33	Economically active population
4	Educational level	10	Quality Index e-government	16	People who have received job training	22	Mobile telephone	28	Companies certified with ISO 9000 and 14000	34	Population aged 18 who lives in a location of more than 100,000 inhabitants
5	Poverty	11	Opened Business	17	Average labor income	23	Internet at homes	29	GDP	35	Total population
6	Net migration	12	Own income	18	Non- oil GDP	24	Direct Foreign Investment (net)	30	New students at the undergraduate level	36	Territory

Source: Own elaboration.

4. Empirical analysis

Due to the excessive quantity of input and output variables, it was proposed to review the correlation between variables, due to the possibility that more than one variable had strongly correlation with another one or other variables part of the study. A correlation matrix was generated with the Excel data analysis as a first step for the ACP. The matrix groups the correlated variables and helps to discard the variables that present multicollinearity.

Due to the study include multiple input and output innovation variables, and not just one output, then it was not selected a multiple regression analysis to reduce the number of variables and validate the efficiency study, but the Principal Component Analysis (PCA). It was used the excel tool of Principal Components, the data were migrated to the Minitab software version 17. Firstly it was obtained a correlation matrix based on the Eigen-analysis, which presented the possibility to reduce from 34 input factors to just 8. The next step was to consider the data within the principal component analysis. The interpretation of the results provided by Minitab is presented in the Table 4.

Tabla 4 Independent variables.

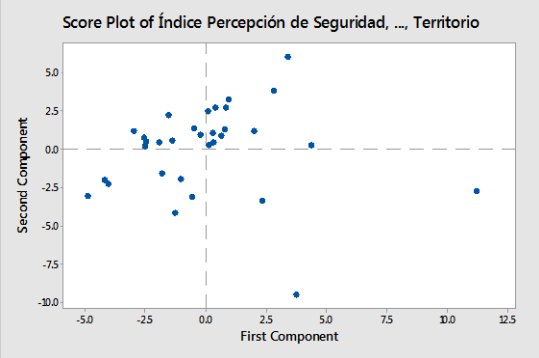
Principal Component Analysis: Índice Perce, Cumplimiento, Escolaridad, Pobreza, Migración ne,

Eigenanalysis of the Correlation Matrix

Eigenvalue	9.4197	8.3715	2.6302	2.2658	1.6718	1.6182	1.5221	1.0735	0.9699	0.8492
Proportion	0.277	0.246	0.077	0.067	0.049	0.048	0.045	0.032	0.029	0.025
Cumulative	0.277	0.523	0.601	0.667	0.716	0.764	0.809	0.840	0.869	0.894
Eigenvalue	0.7250	0.6784	0.4502	0.4041	0.2773	0.2309	0.2123	0.1912	0.1399	0.0822
Proportion	0.021	0.020	0.013	0.012	0.008	0.007	0.006	0.006	0.004	0.002
Cumulative	0.915	0.935	0.948	0.960	0.968	0.975	0.981	0.987	0.991	0.994
Eigenvalue	0.0595	0.0520	0.0341	0.0285	0.0190	0.0133	0.0046	0.0023	0.0010	0.0002
Proportion	0.002	0.002	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
Cumulative	0.995	0.997	0.998	0.999	0.999	1.000	1.000	1.000	1.000	1.000
Eigenvalue	0.0001	0.0000	0.0000	−0.0000						
Proportion	0.000	0.000	0.000	−0.000						
Cumulative	1.000	1.000	1.000	1.000						

Source: Own elaboration.

The key data is the cumulative variance to choose the number of principal components. For this research, 8 factors accumulate 84%, which is significantly acceptable to categorize the principal components. 9 factors were not included because the increment of 3% does not represent a substantial progress. Then, began the analysis of the classification data with the graphical software that generated a graphic for 2 components where it is possible to visualize the grouping for the main components in the following graphic.



Source: Own elaboration.

Graphic 2 Principal Components Trend.

The consecutive step is to decide which component is assigned to each of the variables. It was decided considering the absolute value of each assigned value to one variable.

Table 5. Choice of higher absolute values.

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Índice	0.02	0.161	0.308	-0.016	0.332	0.093	-0.19	-0.157
Cumplimiento	0.07	-0.024	0.38	-0.146	-0.157	-0.077	-0.353	0.126
Escolaridad	0.267	0.115	-0.104	0.074	0.04	-0.093	0.137	0.171
Pobreza	-0.245	-0.135	0.187	0.003	-0.233	-0.05	-0.04	-0.048
Migración	0.083	0.198	0.175	-0.312	0.111	0.292	0.133	0.193
Percepción	0.044	-0.178	-0.196	-0.162	-0.39	-0.124	-0.155	0.02
Aportación	-0.028	-0.321	0.023	-0.133	0.119	0.161	-0.008	0.043
Índice	0.049	-0.034	0.007	0.111	-0.296	0.243	0.453	-0.474
Índice	0.15	-0.175	0.097	-0.052	0.061	0.015	0.278	-0.31
Apertura	-0.047	0.107	-0.094	-0.41	-0.112	-0.414	0.251	0.036
Ingresos	0.265	-0.051	-0.028	0.119	-0.069	-0.264	-0.087	-0.196
Absorción	0.244	0.126	-0.148	0.114	-0.043	0.111	0.089	-0.063
Rendimiento	0.064	0.037	-0.31	0.074	-0.253	-0.054	0.125	0.375
Atracción	0.186	-0.003	0.314	0.026	0.047	-0.059	0.316	0.323
Población	0.03	0.076	-0.254	0.208	-0.175	0.309	-0.311	0.055
Ingreso	0.244	0.167	-0.089	-0.138	0.051	0.085	-0.061	0.046
Participación	0.197	0.109	0.097	-0.089	-0.193	0.391	-0.017	-0.198
Índice	-0.132	-0.192	-0.261	-0.232	0.183	0.153	-0.128	-0.089
Tráfico	0.24	0.113	0.046	-0.258	-0.188	0.013	-0.16	-0.145
Cobertura	0.221	0.107	-0.115	-0.043	0.123	0.216	-0.133	0.152
Viviendas	0.227	0.146	-0.166	-0.148	0.098	-0.012	-0.035	-0.001
Inversión	0.142	0.114	0.118	-0.168	0.116	-0.262	0.042	-0.108
Flujo	0.14	0.066	0.142	-0.35	-0.331	0.074	-0.066	-0.006
Investigadore	0.211	0.035	0.145	0.246	-0.115	-0.228	-0.253	-0.127
Empresas	0.227	0.097	-0.037	0.216	0.254	-0.183	-0.09	-0.191
Empresas	0.17	0.086	-0.111	0.106	0.055	0.059	0.201	0.141
PIB	0.247	-0.185	-0.062	0.077	-0.066	-0.084	-0.08	-0.011
Alumnos	0.198	-0.262	-0.013	0.02	-0.02	-0.051	-0.051	-0.008
Personas	0.128	-0.31	0.024	-0.05	0.081	0.063	0.006	0.076
Población	0.141	-0.306	0.022	-0.045	0.065	0.059	-0.003	0.055
Población	0.137	-0.308	0.025	-0.046	0.062	0.063	-0.007	0.05
Población	0.22	-0.236	0.011	-0.003	0.055	-0.04	0.08	0.075
Población	0.118	-0.315	0.023	-0.054	0.081	0.065	0	0.067
Territorio	-0.034	0.004	-0.377	-0.34	0.239	-0.112	-0.074	-0.276

Source: Own elaboration.

The Principal Components were reduced from 34 to 8 factors.

Table 6. Variables summary of ACP.

Principal Component	Included variables
PC1	3, 4, 11, 12, 16, 20,21, 27
PC2	7, 28,29, 30,31, 32, 33
PC3	2, 6,18,34
PC4	5, 19
PC5	1,23, 25
PC6	10,17, 22
PC7	8, 9, 15, 24, 26
PC8	13,14

Source: Own elaboration.

The last step in the ACP phase is the screening of the original data into the principal component created. The former step is a prelude to the DEA analysis implementation; however before it

should be applied a correlation study of the dependent variables involved as a result of the innovation indicators.

The following variables are called dependent under the present study of innovation exposed in the theoretical framework. The consecutive variables are precursors of innovation, for that reason are included as a result of governmental estate innovation indices.

Table 7. Innovation variables

No.	Variable
1	GDP growth
2	Patents
3	PIB growth of specialized industry
4	PIB growth of specialized services
5	Economic diversification
6	Economic Units

Source: Own elaboration.

As it was previously solved in the independent variables related with innovation, it was decided to generate a correlation matrix to find low correlation between variables. Nevertheless, it was decided not to use the ACP technique, due to the reduced number of variables and the low correlation. Then the following variables were considered as outputs of the DEA study.

Table 8. DEA Correlation matriz of output variables.

		1	2	3	4	5	6
		Patents	Specialized GDP industrial growth	Specialized GDP services growth	Economic diversification	Incomes	Economic units
1	Patents	1.00000					
2	Specialized GDP industrial growth	-0.00076	1.00000				
3	Specialized GDP services growth	-0.04478	0.20048	1.00000			

4	Economic diversification	0.54901	-0.05046	0.026652	1.00000		
5	Incomes	0.25299	-0.00338	-0.46902	0.03179	1.00000	
6	Economic units	0.31960	-0.36948	-0.00452	0.65354	-0.07685	1.00000

Source: Own elaboration.

This was the basis of input / output data with which the DEA analysis was performed. It resulted from the plugin complement of Excel, based on solver, with the efficiency data shown below:

Table 9. DEA results matriz.

			Virtual inpu	Virtual inpu	Virtual inpu	Virtual inpu	Virtual inpu	Virtual inpu	Virtual inpu	Virtual inpu	Virtual outp	Virtual outp	Virtual outp	Virtual outp	Virtual outp	Virtual outputs	
	DMU	Eff. score	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	Patentes	Crecimient	Crecimient	Diversificac	Ingreso de l	Unidades E	Pears --->
1	Aguascalientes	1	41602.52	0.00	0.00	0.00	6.44	4.63	38.55	17.78	1.74	16.28	6.88	750.00	5815.47	49945.00	1(1)
2	Baja California	1	106491.23	0.00	0.00	0.00	3.44	0.00	32.70	20.42	1.46	5.81	3.95	740.00	6919.18	97616.00	2(1)
3	Baja California Sur	1	29665.34	0.00	0.00	0.00	2.59	0.00	13.67	19.56	0.00	11.27	6.44	562.00	9072.18	28266.00	3(1)
4	Campeche	1	189280.75	0.00	0.00	0.00	2.72	5.37	37.03	24.29	0.75	24.04	6.76	533.00	6503.51	36392.00	4(1)
5	Chiapas	1	68387.52	0.00	0.00	0.00	0.54	0.00	31.26	13.07	0.51	3.41	11.59	610.00	3387.92	154513.00	5(1)
6	Chihuahua	1	103801.66	0.00	0.00	0.00	4.08	0.00	37.45	19.93	1.40	4.61	5.76	709.00	6303.52	108869.00	6(1)
7	Coahuila	1	127692.96	0.00	0.00	0.00	4.45	0.00	26.03	19.38	4.05	33.85	12.96	734.00	6096.53	98453.00	7(1)
8	Colima	1	22773.62	0.00	0.00	0.00	3.34	12.41	43.57	19.22	2.02	23.96	9.30	603.00	6960.80	31614.00	8(1)
9	Distrito Federal	1	612633.95	0.00	0.00	0.00	3.70	6.84	5.39	24.48	9.64	-6.22	6.80	935.00	7571.06	428756.00	9(1)
10	Durango	1	47031.22	0.00	0.00	0.00	2.88	0.00	37.90	22.13	0.85	21.64	7.93	734.00	5055.79	55723.00	10(1)
11	Guanajuato	1	146744.95	0.00	0.00	0.00	4.33	12.48	23.06	19.82	3.81	9.53	10.32	744.00	5606.75	211985.00	11(1)
12	Guerrero	1	54482.29	0.00	0.00	0.00	0.14	0.00	42.39	18.48	2.99	-11.98	13.17	598.00	5019.80	149220.00	12(1)
13	Hidalgo	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
14	Jalisco	1	234144.11	0.00	0.00	0.00	2.41	4.77	44.54	20.51	0.26	7.58	5.39	881.00	6396.45	309520.00	14(1)
15	México	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
16	Michoacán	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
17	Morelos	1	44851.95	0.00	0.00	0.00	3.45	11.46	9.25	22.74	4.45	25.23	10.21	694.00	5455.88	94628.00	17(1)
18	Nayarit	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
19	Nuevo León	1	268246.23	0.00	0.00	0.00	5.97	10.77	36.79	21.64	6.37	12.97	6.77	885.00	7270.30	156456.00	19(1)
20	Oaxaca	1	62225.24	0.00	0.00	0.00	0.99	6.59	34.18	7.24	0.12	-4.05	6.84	629.00	4907.82	172743.00	20(1)
21	Puebla	1	122136.93	0.00	0.00	0.00	2.02	5.01	47.29	23.08	3.78	21.48	7.81	820.00	5368.95	155161.00	21(1)
22	Querétaro	1	76177.26	0.00	0.00	0.00	7.07	2.18	16.49	20.20	3.98	16.52	4.25	749.00	6124.46	67096.00	22(1)
23	Quintana Roo	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
24	San Luis Potosí	1	57074.43	0.00	0.00	0.00	3.72	7.98	17.01	14.36	0.82	22.57	10.67	761.00	5350.01	93426.00	24(1)
25	Sinaloa	0.888155	69960.53	0.00	0.00	0.00	1.71	6.65	27.73	17.62	1.61	12.48	8.57	668.00	6745.86	110086.79	3(.21)
26	Sonora	1	110671.49	0.00	0.00	0.00	4.83	0.96	20.42	22.98	3.13	7.12	7.21	732.00	6309.19	101862.00	26(1)
27	Tabasco	0.951075	98918.06	0.00	0.00	0.00	2.49	0.00	18.03	19.59	1.40	11.09	6.43	616.00	7292.30	78959.35	3(.547)
28	Tamaulipas	1	112274.57	0.00	0.00	0.00	2.58	0.00	25.14	21.02	0.72	3.09	6.05	657.00	6086.80	123797.00	28(1)
29	Tlaxcala	1	21924.91	0.00	0.00	0.01	2.04	1.10	29.47	24.02	1.16	12.14	8.74	820.00	4852.37	59633.00	29(1)
30	Veracruz	1	202049.93	0.00	0.00	0.00	0.88	10.01	35.87	18.41	0.83	-0.51	9.44	680.00	5641.87	270359.00	30(1)
31	Yucatán	1	56054.23	0.00	0.00	0.00	4.87	14.15	26.67	19.58	2.36	6.92	5.80	740.00	5420.22	103435.00	31(1)
32	Zacatecas	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

Source: Own elaboration.

5. Results

The DEA matrix shows the entities that still have neither reached the efficient value nor established the required values that each entity need to become 100% efficient and into the frontier. In the case that an entity is already into the efficient frontier, it remains intact.

The algorithm used for the DEA analysis executed in the atmosphere of Excel- solver, identifies which Mexican states can be considered as benchmark in terms of innovation in the national economic sector and which are not into the most relevant variables in order to increase their efficiency. The study of principal components considered the input variables behavior to measure innovation in economic sectors and the influence of those variables, such as those described in the Principal Component Analysis (PCA).

The results that shows the execution of the DEA, refers to state entities that are frontier. However it is important to remark that the DEA analysis does not set as efficient frontier only the states leading to a corresponding variable of an item. The DEA analysis also forms an envelope surface data where some entities may appear as efficient frontier despite they do not lead any specific variable. The election based on the consideration that an envelope surface data is formed by boundary lines where one can locate entities as tangent points and not precisely vertices of the mentioned surface.

The data presented in the last column of the table refers to those values associated with the slack of variables. Those values have the function of coupling, according to the mathematical model, the iterations results for each DMU which is not efficient. The slack created for the DMU's that do not belong to the efficient frontier is relevant to the orientation of state inputs according to the variables presented. The results show a broad spectrum of work within the framework of innovation. The efficient frontier model allows knowing the levels of technical efficiency for the state entities.

This applied research applied the DEA technique, as analytical instrument, catalogue the Mexican estate entities to categorize them according to the efficient frontier and be able to increase the innovation level. The innovation measurement of the Mexican state entities allows the identification of the most efficient states in the country; as well as the variables that contribute or not to that national objective within the country. Among the identified opportunity areas are where state entities can improve their identified "inputs"; or, their "outputs" to get closer to the identified efficiency frontier with the DEA analysis. Consequently, it is crucial that from the opportunity areas identified, new public policies can be generated to fill the gaps at the national level.

The innovation variables recognize a wide factors range involved in the state institutions as competitiveness means. Regarding the principal component analysis, it is shown a little difference between social variables interrelated in the innovation field. According to the innovation framework, it is concluded that the variables related with the innovation development are strongly interrelated, then it allows that each state entity be efficient in some aspect of the theoretical framework according to the established government policies.

6. Conclusions

This analysis based on the data envelopment analysis (DEA) allows contrasting the innovative Mexican state factors with other index results such as the one of the Foro Consultivo Científico y Tecnológico (FCCyT). Comparing both results, the FCCyT displays the states highlighted in the following order: Distrito Federal, Nuevo León, Querétaro, Jalisco and Morelos. By contrast in the present research, after Distrito Federal and Nuevo León the study reveals the state of Morelos. That state entity was the last one of the highlighted in the FCCyT index. One of the

main reasons of this difference could be the analytical technique -DEA-, due to it helps the decision makers to visualize the whole variables considered into this study which were 36 taking into account besides the economic variables, the infrastructure, educational and social ones.

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