EXPLORING CORRUPTION AND INNOVATION DYNAMICS IN THREE MEXICAN FEDERAL ENTITIES

EXPLORANDO LA DINÁMICA DE LA CORRUPCIÓN Y LA INNOVACIÓN EN TRES ENTIDADES FEDERALES MEXICANAS

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ABSTRACT: This research reviews the "grease the wheels" and "sand the wheels" hypotheses about the positive or negative effects of corruption on innovation in federal entities of Mexico. There are two levels of study of these hypotheses, at the company level through surveys that capture the bribery variable, or through studies of macro indicators, with the perception of corruption variable. This study is inserted in the second perspective at the macro level. The work was carried out using multivariate analysis methodologies, on the one hand, with principal component analysis, and on the other with case studies. With the analysis of principal components, it is concluded that both hypotheses could be fulfilled only for some federal entities. With the analysis of case studies, we show the contexts in which every hypothesis works in Nuevo Leon (grease the wheels) and for Durango and Zacatecas (sand the wheels). This has important implications, since if these results are considered, innovative activity policies could improve if the vices imposed by corruption are combated, since this would release some transaction costs for companies derived from these activities, therefore, larger budgets do not necessarily lead to better results in science and technology.

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RESUMEN: En esta investigación se revisan las hipótesis de "*grease the wheels*" y "*sand the wheels*" sobre los efectos positivos o negativos de la corrupción en la innovación en las entidades federativas de México. Se tienen dos niveles de estudio de dichas hipótesis, a nivel de empresa a través de encuestas que captan la variable de soborno, o a través de estudios de indicadores macro, con la variable de percepción de corrupción. Este estudio se inserta en la segunda perspectiva a nivel macro. El trabajo se realizó utilizando metodologías de análisis multivariado, por un lado, con análisis de componentes principales, y por otro con estudios de caso. Con el análisis de componentes principales se concluye que ambas hipótesis podrían cumplirse sólo para algunas entidades federativas. Con el análisis de estudios de caso se muestran los contextos en los que cada hipótesis funciona en Nuevo León (*grease the wheels*) y para Durango y Zacatecas (*sand the wheels*). Esto tiene implicaciones importantes, ya que, si se consideran estos resultados, las políticas de actividades innovadoras podrían mejorar si se combaten los vicios que impone la corrupción, ya que esto liberaría algunos costos de transacción para las empresas derivados de estas actividades, por lo tanto, mayores presupuestos no necesariamente conducen a mejores resultados en ciencia y tecnología.

Palabras clave: *corrupción, innovación, crecimiento económico, componentes principales, ecuaciones estructurales*

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INTRODUCTION

Schumpeter stands as a prominent figure in examining the impact of innovation on development and economic growth, with his notable contribution being the concept of creative destruction. He posited that innovative companies bring forth novel approaches, ultimately displacing non-innovative counterparts within the market. This phenomenon, coined as "creative destruction," encapsulates the transformative nature of innovation. Schumpeter's extensive work, spanning from 1939 to 1942, emphasizes technological change as the primary driving force propelling capitalism forward.

Several other schools of thought align with this perspective, including the evolutionary approach (Lovera et al., 2008), neoclassical theory (Solow, 1957; Mankiw et al., 1992), institutionalist views (North, 1990), and structuralist analysis (Floto, 1989). The evolutionary perspective highlights how innovation emerges as a result of organizational learning within companies. Neoclassical theory, on the other hand, considers innovation as a catalyst for economic growth by introducing new pathways in the production function. Institutionalists argue that innovation is shaped by a set of formal and informal rules, which can either hinder or facilitate innovative activities through agreements between universities, companies, governments, and society at large. Meanwhile, structuralists contend that there exists a dichotomy between technological and non-technological sectors, with innovation predominantly occurring in industrialized center countries, while peripheral nations primarily engage in the commercialization of primary goods without generating substantial innovations. Thus, the study of innovation becomes a crucial component in explaining economic growth, particularly in developing countries where it underscores the importance of devising effective promotion policies.

The process of innovation is shaped not only by economic conditions but also by sociopolitical factors. This holds true, particularly in developing countries, where the long-term nature of innovative processes introduces risks associated with corruption (Murphy, Shleifer & Vishny, 1993). The uncertainty stemming from corruption extends beyond third-party involvement, affecting the companies themselves. The absence of bribes as a form of payment creates uncertainty that hampers the execution of long-term technological development projects (Karaman & Sylwester, 2020). This issue is not confined to developing nations alone; it also impacts innovative processes in certain regions of the United States (Alt & Lassen, 2003; Glaeser & Saks, 2006; Riaz et al., 2018) and other developed countries. Consequently, the relationship between corruption and its impact on innovation becomes a significant concern for regional development, as it can impede progress in these areas.

Within the literature, two competing hypotheses emerge to elucidate the effects of corruption on innovation (Huang & Yuan, 2020; Ellis et al., 2020; Karaman & Sylwester, 2020). The first hypothesis contends that companies operating in corrupt environments can derive benefits from such circumstances, facilitating increased innovation. Corruption, in this perspective, acts to surmount bureaucratic hurdles by granting access to valuable resources and even enabling interaction with state services and products –an effect colloquially referred to as "grease the wheels". Conversely, the second hypothesis posits that corruption practices hinder innovative processes within companies. Seen as a form of tax, corruption inflates the costs associated with innovative

endeavors, creating a bias towards rent-seeking behaviors, and discouraging genuine innovation– a phenomenon aptly labeled as "sand the wheels".

The objective of this study is to test the hypotheses for the case of Mexico. To achieve this, a mixed methodology is proposed, combining multivariate analysis of principal components for corruption and innovation indicators. This approach enables the categorization of states that may exhibit high corruption levels and varying levels of innovation. By identifying these states, it becomes possible to contrast the hypotheses presented in the previous paragraph. Subsequently, each identified entity is characterized to further examine and compare the hypotheses.

The study is structured as follows: in addition to this introduction, the study contains a literature review section, where the main concepts, hypotheses, and the state of the art of studies on the effects of corruption on innovation are exposed. The following section is a description of the methodology and techniques used to test the hypotheses of this work. Then a results section is added. Finally, the conclusions, where it is discussed if any of these hypotheses explain the effects of corruption on innovation in Mexico, as well as to know if these finally have effects on economic growth.

THE EFFECTS OF CORRUPTION ON INNOVATION

As Iorio and Segnana (2022) have pointed out, although the connection between innovation and corruption has been pervasive, scholars have yet to establish the exact nature of this relationship. The growth in the availability of data on corruption and innovation has contributed to the growth of this type of study (Doan et al., 2022). These studies can be divided by levels of analysis, the first type are studies at the company level, where through surveys the effect of corruption on innovations is analyzed, whether in micro, small and medium-sized companies (MSME), large companies and even multinational companies. The second type is made up of studies at the country level. In this type of study, the effects of corruption on innovative activity in developed and developing countries are analyzed, and even at the regional level with groups of countries in Africa, Asia, Europe, or America.

One of the reasons why the effects of corruption on innovation have been considered is because companies with higher growth rates and higher profit margins are associated with higher levels of innovation (Karaman & Sylwester, 2020). On the other hand, companies that make higher investments generally expect to have higher levels of utility to face their levels of leverage, which is why they need to innovate (Ross et al., 2012), and additionally require greater

certainty about the institutions to carry out innovative activities (Riaz et al., 2020; Habiyaremye & Raymond, 2013).

These effects can be observed both at the MSME level, as well as in large companies, since there is a record of academic studies of these affectations in companies such as Samsung, Siemens, WalMart, among others (Iorio and Segnana, 2022). Therefore, the size of the companies is not a factor that inhibits or prevents corruption, but that corruption takes different forms in the different sizes of companies. It is for this reason that at the company level:

- Iorio & Segnana (2022). They argue that both "grease the wheels" and "sand the wheels" hypotheses can coexist, and that they are not necessarily competing hypotheses. In this sense, it is pointed out that some types of corruption such as bribery tend to support one of the hypotheses, while political or large-scale corruption supports another of the hypotheses.
- Doan et al. (2022). This paper shows that there is an impact on corruption found in tax collection and innovative activity. Evidence is found that bribes on payment of taxes have a positive effect on all innovation indicators.
- Riaz & Cantner (2020). In this study, the effects of corruption on innovation are analyzed, but it is differentiated by type of corruption, with different indicators. The authors differentiate the effects by type of innovation and type of industry, since not all companies compete in the same contexts, nor do all companies innovate in the same areas. The study finds that small bribes work to increase the level of process innovation but have negative effects on organizational innovations. While companies involved in large amounts of corruption are more likely to innovate in products and processes. Political corruption is mostly associated with all types of innovation except obtaining quality certificates. They also point out that innovation in the service sector is more related to petty bribes than the manufacturing industry.
- Karaman & Sylwester (2020). They show that bribery is significantly associated with innovation, but significant results are only seen for firms that report many competitors. One explanation for this behavior is that competition forces companies to innovate, and in this sense, corruption allows them to avoid costly regulations.
- Huang & Yuan (2020). They show that although rogue states have a lower fraction of firms operating in government-reliant industries, firms in these states are more likely on average to be government suppliers.

On the other hand, this study indicates that there is a negative impact of corruption on innovation, especially for companies with less bargaining power over government officials, so that corrupt practices to obtain government contracts replace innovative practices, of entrepreneurship and greater competition.

- Ellis et al. (2020). Corruption has negative effects, not only on innovation, but also on the quality of innovation (as measured by patent citations).
- Wellalage et al. (2020). They examine whether bribery affects gender-based asymmetries in product/process innovation in developing countries. They find that there are greater incentives for female business owners to give bribes than the incentives for an owner. They find evidence in favor of the "grease the wheels" hypothesis.
- Sena et al. (2018). They point out that independent boards of directors can insulate a company from the detrimental impact of corruption on its performance (as represented by innovation).
- Karaman (2017). Their results indicate that corruption has a positive effect on the innovation rate, regardless of how innovation and corruption are measured.
- Nguyen et al. (2016). In their study on companies in Vietnam, they point out that informal payments (bribes) tend to increase the level of innovation, be it product improvements or the generation of intellectual property. They point out that the impacts of corruption are not uniform since they are subject to the effectiveness of local institutions. In this same document, it is pointed out that bribery affects the growth of MSMEs, but not so much of large companies, while large companies generally do so of their own free will. In this study, it is also pointed out that multinational companies, when they use corrupt practices, retard innovative activity in the host country.
- Habiyaremye & Raymond (2013). There are two perspectives on the operations of multinational companies, and their relationship with corruption and innovation activities. One is that transnational corporations inhibit corruption, and the other is that they increase it. One argument why it increases is that these multinationals use bribes to compete in host countries, and therefore inhibit the innovation of other companies, since the economic power of multinationals is considerable, and therefore the rest of the companies are better off. they are engaged in rent-seeking and less innovative activities. The arguments for the reduction of corruption are due to the greater scrutiny of the public

eye in large and international companies, and on the other hand to the spillovers of technology that these imply, suppose higher levels of innovation.

- Mahagaonkar (2010). It shows contradictory results, on the one hand, there is evidence that corruption helps innovation in marketing. On the other hand, it inhibits product, process, and organizational innovation. Four dimensions of positive transmission mechanisms are mentioned, the first says that it speeds up the permit and license processes; the second says that corruption or the payment of bribes reduces uncertainty when looking for incremental innovation; the third is that the political obstacles derived from some innovations (bioethical discussions, for example) can somehow be overcome; Finally, derived from the payment of bribes, some level of protection from organized crime and vandalism is maintained, which helps to give companies certainty. A negative channel of corruption on innovation is that the bureaucracy discourages projects that involve large uncertainties, this is especially true if the projects are financed by the government rather than privately.

There are also studies at the macro level. These types of studies, which can refer to a country, a group of countries, or a group of states within a country, have reached somewhat different findings from studies at the company level. Some of them are described below:

- Wen et al. (2018). There is a threshold or tolerable limit of corruption, and that, after this limit, the effects of corruption on innovation are almost null. Using instrumental variables, they show that there is a non-linear relationship between innovation and corruption, but that corruption affects the granting and application of patents more strongly than trademark registrations. One of the arguments proposed in this work is that there are problems of endogeneity, derived from the protection of patents, since this temporary monopoly sometimes leads companies to corrupt activities to compete.
- Tomaszewski (2018). Corruption can be compared to a typical market transaction, where buyers (the corrupt agents) meet sellers (the corrupt agents), the object of the transaction is the solution to the problem of the corrupt agent and the price is the bribe. and whose exact nature is subject to negotiation between the two parties.
- Riaz et al. (2018). They use the Granger causality test for panel data, find that corruption causes innovation, while innovation does not cause

corruption. Therefore, they deny the existence of a double direction of causation.

- Anokhin & Schulze (2009). Better control of corruption will be associated with increasing levels of innovation and entrepreneurship. The results, while not explicitly predicting economic growth, add to a stream of research that suggests that corruption and the quality of institutions play an important role in explaining disparities in rates of entrepreneurship and innovation.
- Griffiths & Kickul (2008). Corruption leads to a misallocation of resources, a lack of competitiveness and efficiency, lower public revenues for essential goods and services, lower productivity, and lower levels of innovation, in addition to lower rates of growth and employment in the private sector. They point out that policies aimed at reducing perceived government corruption, along with R&D funding and resources from the private business/industrial sector may be some of the first priorities to lessen the impact of corruption on innovation.

Both at the company level and at the country level, the conclusions and the direction of the investigations suggest different conclusions. At the company level, it is necessary to differentiate between small companies, which are generally forced to offer small bribes, large companies that participate in corruption activities of their own free will, or multinationals that through corruption inhibit innovative performance. At the country level, the studies are distinguished by their direct focus on corruption on innovative activity, and indirect focus on corruption on economic growth. The review of the state of the art shows that some of these studies propose an endogeneity or double direction, of an effect of corruption on innovation, but also of innovation on corruption.

Due to the availability of information in Mexico, the study that is proposed is at the level of federal entities, for which reason the applications and granting of patents, industrial designs and utility models are proposed as an innovation variable, since there is no a precise follow-up of patent citations at the federal entity level and, on the other hand, there are no surveys at the company level (at least public), which account for the levels of innovation in product, process, service or organization.

METHOD, VARIABLES AND SOURCES OF INFORMATION

To carry out this study, variables from different sources of information, all of them secondary, have been taken up. The variables used are all at the federal entity level and can be grouped by categories. For reasons of availability of variables that show the performance of corruption by federal entity, since there is only the ENCIG survey, the study focuses only on the analysis of three years in which the survey is published, which are 2015, 2017 and 2019. The variables and their sources of information are described below.

- *Innovation variables.* Within these variables there are three sources of information, on the one hand, CONACYT from which the number of members of the National System of Researchers is extracted; we also have the IMPI, from where applications and granting of patents, utility models and trademark registration are extracted; Finally, there are budget variables, extracted from the official newspapers, official newspapers and public accounts of each state, from which the expenditure dedicated to science and technology is taken up. Finally, from the national public account, the amount dedicated to the SEP by each state is extracted, as education spending.
- *Corruption variables.* The corruption variables are taken from the National Survey of Government Quality and Impact (ENCIG), which is carried out by INEGI. From where there are 21 variables of perception of corruption, among them the perception of corruption in state, federal and municipal governments, perception of corruption in businessmen, police, hospitals, universities, etc. These perceptions range from 0 to 100 where zero is the least corrupt and 100 is the most corrupt.
- *Control variables*. Other variables that help in the present analysis are taken up, such as population, extracted from CONAPO. Direct Foreign Investment, taken from the Ministry of Economy. Growth of the Gross Domestic Product of the states, taken from INEGI. Finally, from the public accounts and official newspapers of each state, the variable of total expenditure by federal entity is extracted.

All these variables and their sources of information are summarized in Table A1 in the annexes section.

Principal Component Analysis

In this study, a dimensional reduction of variables is applied using Principal Component Analysis (PCA). Since this procedure gives us a decomposition of the total variance, this allows us to know precisely what percentage of it we could lose if we eliminate a particular principal component. The importance of the different principal components is given by the magnitude of their variance and, therefore, the order in which they are obtained establishes a real hierarchy from the point of view of dimensional reduction.

To obtain the principal components, we need to have a sample of size n with p variables X1, X2,..., Xp, where the variables are expressed in deviations from the mean, also called standardized variables. The first component will be given by the linear combination of the standardized variables

$$Z_{1i} = u_{11}X_{1i} + u_{12}X_{2i} + \cdots + u_{1p}X_{pi} \qquad (1)$$

Therefore, this implies that the mean of Z1 is equal to zero, on the other hand, in matrix notation, the previous expression would be given by:

$$\boldsymbol{z_1 = Xu_1} \qquad (2)$$

To find the first component, the maximum variance restrictions are imposed, subject to the sum of the squared "u1j" weights being equal to one, which implies that:

$$var(Z_1) = \frac{\sum_{i=1}^{n} Z_{ij}^2}{n} = \frac{1}{n} u_1 \acute{} X \acute{} X u_1 \qquad (3)$$

Therefore, by incorporating the restriction of the variances equal to unity, an equation with restrictions in Lagrange form can be established:

$$L = \frac{1}{n} u_1 \acute{} X \acute{} X u_1 - \lambda(u_1 \acute{} u_1 - 1) \qquad (4)$$

Therefore, when applying the optimization algorithm, through the partial derivatives with respect to u1, the last equation is obtained.

$$\left(\frac{1}{n}X'X - \lambda I\right)u_1 = 0 \qquad (5)$$

Therefore, when solving equation (5), the eigenvalues and eigenvectors are obtained, where the eigenvectors correspond to the principal components, while the eigenvalues correspond to the variances associated with the vector. Therefore, if more principal components need to be calculated, the matrix of variances and covariances can be rotated with some method, to obtain more uncorrelated components.

In this study, the PCA technique is applied to reduce the number of variables associated with innovation, and another number of components associated with corruption. In Table A1, we have 21 variables associated with corruption, and in terms of innovation we have 9 variables, which can be reduced using this PCA technique.

Some important measures to apply the PCA, is the KMO "*Kaiser Meyer*" statistic, which refers to the suitability of a matrix to apply a PCA and/or a Factor Analysis. The statistic refers to a quotient of the sum of all the correlations squared divided by the square of the sum of the correlations of each variable.

$$KMO = \frac{\sum_{i \neq j} \sum r_{ij}^2}{\sum_{i \neq j} \sum r_{ij}^2 + \sum_{i \neq j} \sum a_{ij}^2} \qquad (6)$$

Therefore, KMO statistics lower than 0.5 are discarded for a PCA, since the contribution of the variable to the information matrix is limited. Additionally, to evaluate the necessary number of principal components, eigenvalues greater than unity are taken up, or a contribution to the variance greater than 70%, which is achieved by sedimentation graphs or with a cumulative variance sum.

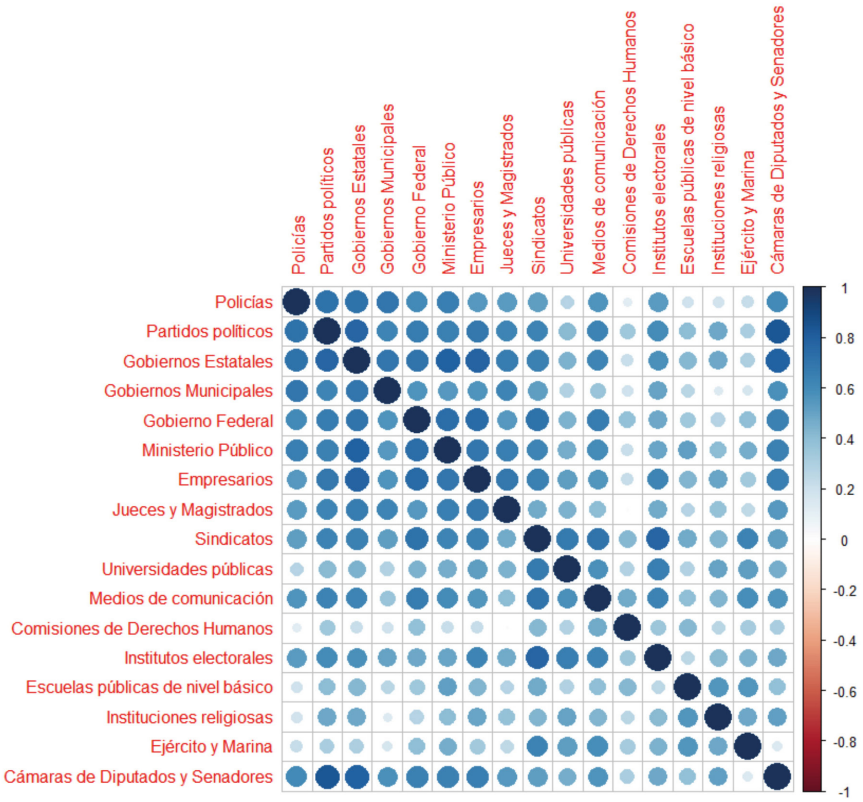
Once the main components of variables related to innovation and corruption have been obtained, descriptive tables are generated with the quartiles of each main component, which describe the relationships between corruption and innovation, to classify the entities according to the hypotheses.

RESULTS

Results of the PCA

This section presents the results of the principal component analysis for both corruption indicators and innovation indicators. In this regard, the correlation statistics of the indicators are first displayed, followed by the PCA procedure. Based on these results, a classification table of federal entities is presented.

GRAPH 1. CORRELATION COEFFICIENTS FOR CORRUPTION VARIABLES IN 2019



Source: The Author, with data from INEGI. The chart was built in Rstudio.

From Graph 1, all the correlations between these variables are positive, that is, the greater the correlation in any of the dimensions, the greater the perception of corruption of the rest of the variables, which is consistent with the literature review. due to endogeneity issues.

From these correlation coefficients, all the KMO coefficients were calculated to see if, at the individual and global level, they are significant correlations, and with this a principal component analysis can be performed. The results are shown in Table 1.

TABLE 1. KMO COEFFICIENTS OF CORRUPTION INDICATORS FOR 2019

Variable	KMO
MSA global	0.83
MSA for each variable:	
Police	0.86
Political parties	0.85
State Governments	0.89
Municipal Governments	0.79
Federal Governments	0.80
Public ministry	0.84
Businessman	0.85
Judges and magistrates	0.82
Unions	0.86
Public Universities	0.82
Media	0.88
Human Rights Commissions	0.74
Electoral Institutes	0.83
Public Schools	0.73
Religious Institutions	0.81
Army and Navy	0.74
Chamber of Deputies and Senators	0.79

Source: The Author, with data from INEGI.

From Table 1, it can be concluded that the set of corruption indicators is suitable for a principal component analysis, since they have a strong correlation between them (see global MSA), on the other hand, at the individual level all the corruption indicators have a correlation with the group of variables, so none of them is excluded, it is recommended to discard any when the KMO coefficient is less than 0.5.

From the principal component analysis (PCA), it is found that three of its components have an accumulated variance greater than 70% (see Table 2), so these three main factors are the ones that are taken up for subsequent analysis. On the other hand, the first three components accumulate a total of 71% of the total variance of the data (see Table 4), thus confirming the use of three components.

TABLE 2. SUMMARY OF THE ACP FOR CORRUPTION INDICATORS IN 2019

	PC1	PC2	PC3
Standard deviation	3.0304	1.3761	1.0207
Variance proportion	0.5402	0.1114	0.06128
Cumulative ratio	0.5402	0.6516	0.71288

Source: The Author.

From the PCA, it can be verified that three corruption indicators (components 1, 2 and 3) have the capacity to reduce the information of 17 corruption indicators, and still preserve an explanation of 71% of the variation of the data. These components are used to describe the way in which the corruption indicators are related to each other.

In addition to this analysis, Table 3 shows the PCA factor loads. These loads refer to the correlations between the score of each principal component with the original variables.

TABLE 3. FACTOR LOADINGS FOR CORRUPTION INDICATORS IN 2019

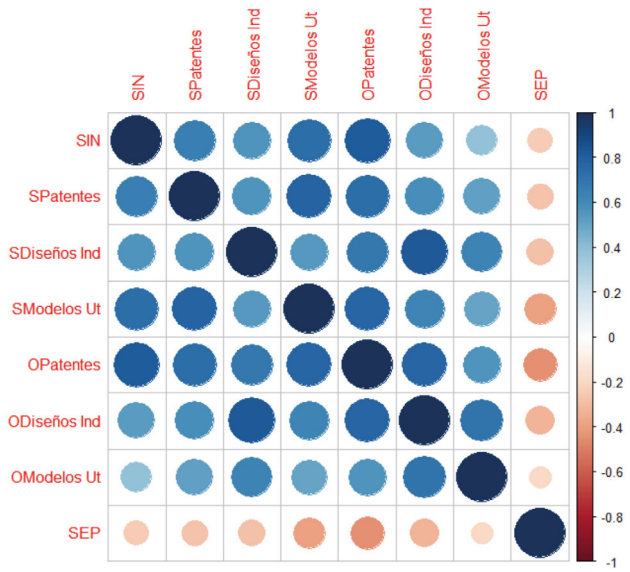
	PC1	PC2	PC3
Police	-0.73	0.43	-0.19
Political parties	-0.85	0.19	0.05
State Governments	-0.88	0.26	0.14
Municipal Governments	-0.69	0.44	-0.13
Federal Governments	-0.82	0.11	-0.16
Public ministry	-0.83	0.11	0.15
Businessman	-0.84	0.12	0.14
Judges and magistrates	-0.71	0.34	0.22
Unions	-0.84	-0.24	-0.26
Public Universities	-0.66	-0.34	-0.12
Media	-0.79	-0.24	-0.25
Human Rights Commissions	-0.42	-0.47	-0.29
Electoral Institutes	-0.76	-0.12	-0.33
Public Schools	-0.55	-0.44	0.44
Religious Institutions	-0.58	-0.40	0.53
Army and Navy	-0.55	-0.62	-0.04
Chamber of Deputies and Senators	-0.80	0.23	0.18

Source: The Author. Cells in yellow show the most significant factor loadings on each component.

In the first component, the strongest factorial loads are captured, which is why this component contributes 54% of the total variance of the data. In the second component, the factorial loads of human rights commissions and the army and navy are found, while in the third component there are the factorial loads of public schools and religious institutions.

Regarding the above, the same exercise that was carried out for the corruption indicators was carried out for the innovation indicators, for which the same procedure is followed, first showing a graph with the expressions of the correlation coefficients.

GRAPH 2. CORRELATION COEFFICIENTS FOR INNOVATION VARIABLES IN 2019



Source: The Author, with data from INEGI. The chart was built in Rstudio.

In Graph 2, the only variable that has a negative relationship with the rest of the innovation indicators is the SEP state expenditure variable, in addition to the fact that it has the weakest correlations with the rest of the indicators. As in the previous PCA, before applying the technique, the KMO coefficients were calculated to verify if the PCA is viable in innovation indicators as a variable reduction technique. The results are shown in Table 4.

TABLE 4. KMO COEFFICIENTS OF INNOVATION INDICATORS FOR 2019

Variable	KMO
MSA global	0.81
MSA for each variable:	
N.S.R.	0.74
Patent application	0.86
Industrial design Application	0.82
Utility models Application	0.85
Patent granted	0.79
Industrial design granted	0.76
Utility model granted	0.93
SEP	0.67

Source: The Author, with data from CONACYT, SEP and IMPI.

From Table 4, it can be seen that all the variables as a whole have a close relationship, which is why they must be included as a whole (see global MSA), in addition to the fact that the variables at the individual level have a significant relationship with the set of variables, so none of them is ruled out. Due to the above, a PCA was carried out with the innovation indicators for the year 2019, the results indicate that two of the main components are significant, but on the other hand, two of these components capture 74% of the total variation of the data (see PCA summary table), so the PCA variable reduction technique manages to reduce to two components the total of eight variables.

TABLE 5. SUMMARY OF THE ACP FOR INNOVATION INDICATORS IN 2019

	PC1	PC2
Standard deviation	2.247	0.9569
Variance proportion	0.631	0.1145
Cumulative ratio	0.631	0.7455

Source: The Author.

This PCA, in addition to capturing 74% of the total variation of the data, shows the relationship that exists between each indicator, and the score achieved by each of the federal entities, where two directions are shown that the states have taken in relation to with its innovation indicators. On the one hand, some states opt for higher SEP spending, utility model and industrial design grants,

and more industrial design applications. On the other hand, other states opt for greater intensity in SNI members, granting and application of patents, in addition to applications for utility models. Finally, there is a group of states that have not opted for this development of innovation indicators, but are going in the opposite direction, without developing these innovation capacities.

In addition to this graphic analysis, the factor loadings of the innovation components were obtained, which are shown in Table 6.

TABLE 6. FACTOR LOADINGS FOR INNOVATION INDICATORS IN 2019

	CP1	**CP2**
N.S.R.	0.80	0.20
Patent application	0.83	0.10
Industrial design Application	0.82	-0.32
Utility models Application	0.86	0.23
Patent granted	0.93	0.14
Industrial design granted	0.86	-0.29
Utility model granted	0.72	-0.47
SEP	-0.45	-0.62

Source: The Author.

Table 6 shows that the first component captures most of the factor loads, which is why this component captures 63% of the total variance of the data, while the second component has a load strong factorial in SEP expenses, as seen in the previous graphic analysis, these charges explain the movement of some of the states in their development strategies of innovation indicators.

Based on these PCA, table 7 was prepared, which contain crosses of the main components, on the one hand, the first main component of corruption indicators against the first component of innovation indicators, which captures 54% of the variance of indicators. of corruption and 63% of the variance of innovation indicators. These tables serve as tools for classifying entities based on their performance in these variables.

TABLE 7. CLASSIFICATION OF ENTITIES ACCORDING TO THE FIRST COMPONENT OF EACH ACP

		First component of corruption			
		First quartile	Second quartile	Third quartile	Fourth quartile
First component of innovation	First quartile	CDMX, JAL, MOR	AGS, COAH, QUE	GUA	NL
	Second quartile		MEX, PUE	COL, HID, SON	CHIH, SIN, YUC
	Third quartile	BC, MICH, QROO, SLP, VER		CAM	BCS, TAM
	Fourth quartile		CHIA, GUE, OAX	NAY, TAB, TLAX	DUR, ZAC

Source: The Author, based on ACP results.

From Table 7, the classification of entities according to their main components can be better appreciated, since there are entities that are in the highest quartile of innovation, but at the same time in the lowest quartiles of perception of corruption, such This is the case of Mexico City, Jalisco, and Morelos. There are also entities in the highest quartile of innovation, but with high levels of perception of corruption, such is the case of Nuevo León, but also entities with high perception of corruption and low quartile of innovation such as Durango and Zacatecas. These last three entities are going to be our subject of study at individual level.

Results of Case Studies

According to the previous table, the states of Durango and Zacatecas could potentially exemplify a "sand the wheels" scenario, while Nuevo León could represent a "grease the wheels" case of corruption influencing innovation. A brief economic and population description of these three entities is provided below, which will aid in understanding the context of the present study.

TABLE 8. ECONOMIC VOCATIONS

Durango		**Zacatecas**		**Nuevo León**	
Sector	Share	Sector	Share	Sector	Share
Electricity, Water and Gas Generation, and Transmission	29.9	Mining	22.6	Electricity, Water and Gas Generation, and Transmission	35.4
Corporates	18.9	Manufacturing	12.7	Corporates	21.5
Mining	12.7	Commerce	12.2	Manufacturing	7.8
Commerce	6.7	Mass Media Information	10.1	Financial and Insurance Services	5.8
Financial and Insurance Services	6.3	Financial and Insurance Services	8	Commerce	4.3
Manufacturing	5.5	Construction	6.3	Mass Media Information	3.4

Source: The Author with data from INEGI.

Upon initial analysis, it is evident that the three entities share similar productive vocations, as commerce, manufacturing, financial and corporate services, hold significant prominence within each state. However, fundamental differences also emerge. For instance, mining stands as a crucial activity in Durango and Zacatecas, while it is not prominent in Nuevo León. Another distinguishing factor is the presence of mass media information, which holds importance for Nuevo León but not for Durango and Zacatecas.

This observation highlights both the commonalities and distinctions among the states. While they exhibit comparable strengths in sectors such as commerce, manufacturing, and financial services, specific industries set them apart. The mining sector, for instance, plays a crucial role in the economic landscape of Durango and Zacatecas, contributing to their distinct industrial profiles. On the other hand, Nuevo León stands out due to its focus on mass media information, which drives its economic activities in that sector.

This analysis underscores the importance of considering the unique economic characteristics of each entity, as they shape their respective environments and potentially influence the relationship between corruption and innovation within them.

TABLE 9. POPULATION AND GDP PER CAPITA (2019)

	GDP ($MX)	Population	GDP per capita
Durango	204,061,056,000	1,832,043	111,384
Zacatecas	151,905,742,000	1,623,186	93,585
Nuevo León	1,373,350,630,000	5,370,849	255,705

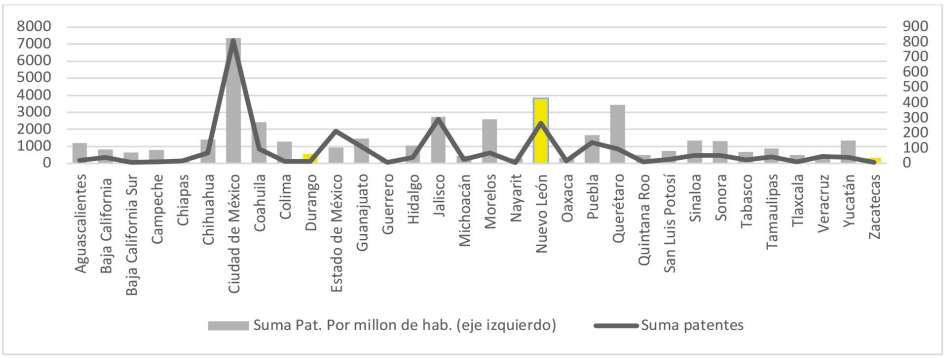
Source: The Author, with data from INEGI.

Nuevo León appears to have a significantly higher per capita GDP than Durango and Zacatecas, more than double their respective figures. This suggests that Nuevo León demonstrates greater productivity, which can potentially be attributed to having less extractive vocations such as mining and trade. These extractive activities, to some extent, may hinder the generation of innovations in the form of patents, as their primary objective is value extraction rather than value creation. Moreover, these value-extractive activities often require special permits, which can more easily lead to corrupt practices.

The higher per capita GDP in Nuevo León indicates a higher level of economic development and productivity compared to Durango and Zacatecas. This discrepancy could be attributed, at least in part, to the different economic activities pursued in each state. Nuevo León's economic landscape, characterized by a focus on sectors such as manufacturing and financial services, fosters higher value-added activities that contribute to greater productivity.

On the other hand, the presence of extractive sectors like mining and trade in Durango and Zacatecas might impede the generation of innovative solutions and hinder the development of patents. These industries primarily focus on extracting and exploiting existing resources rather than creating new value through innovation. Additionally, the nature of extractive activities often involves obtaining special permits and dealing with regulatory processes, which can create opportunities for corrupt practices.

GRAPH 3. PATENTS PER FEDERAL ENTITY (1993-2022)



Source: The Author, with data from IMPI.

The above graph presents the patenting outcomes across federal entities, revealing that Durango and Zacatecas exhibit relatively poor performance in innovation, whereas Nuevo León demonstrates one of the highest levels of innovation. This discrepancy can be partly attributed to the potential impact of corruption on hindering greater patenting in the productive sectors of Durango and Zacatecas. However, it is also worth considering that Nuevo León, being an entity with a higher per capita GDP, may face increased public scrutiny. Consequently, corrupt activities may not necessarily impede innovation but instead be more tolerated or less pervasive in Nuevo León.

The contrasting patenting trends observed in the figure raise important questions about the influence of corruption on innovation outcomes. The low patenting rates in Durango and Zacatecas could reflect a combination of factors, including the potential deterrent effect of corruption on innovative activities and limited resources allocated to research and development. Conversely, Nuevo León's strong performance in patenting may be associated with a more conducive environment for innovation due to factors such as higher economic prosperity, better governance, and a stronger innovation ecosystem.

The examination of patenting figures in relation to corruption highlights the complex dynamics at play. It underscores the need for further research to better understand the specific mechanisms through which corruption affects innovation and how different economic, social, and governance factors interact in shaping innovation outcomes across federal entities. By gaining deeper insights into these dynamics, policymakers can devise targeted strategies to foster innovation, address corruption, and promote sustainable economic growth and development.

CONCLUSIONS

The paper delves into the complex relationship between corruption and innovation, exploring two contrasting hypotheses: "grease the wheels" and "sand the wheels." It posits that these hypotheses can be applicable to specific federal entities based on the empirical analysis conducted. The study focuses on Nuevo Leon, Durango, and Zacatecas, examining the unique contexts in which corruption manifests itself in these regions. In Nuevo Leon, corruption seems to "grease the wheels" by facilitating innovation, while in Durango and Zacatecas, corruption appears to "sand the wheels" and hinder innovation.

By showcasing these distinct scenarios, the paper aims to provide insights into the diverse outcomes of corruption on innovation across different regions. It highlights the importance of considering local contexts and dynamics when analyzing the impact of corruption on innovative activities. Understanding these variations can help policymakers and stakeholders develop tailored strategies to address corruption effectively and promote innovation.

Additionally, the paper suggests that combating corruption can yield positive effects on innovation by reducing transaction costs for companies. Corruption often leads to additional expenses, inefficiencies, and delays in various processes, creating obstacles for businesses, particularly in the fields of science and technology. By implementing measures to address corruption, such transaction costs can be minimized. Consequently, companies can allocate their resources more efficiently, fostering an environment that is conducive to scientific and technological advancements.

The implications of this finding are significant. A reduced prevalence of corruption would not only benefit individual companies by streamlining their operations but also contribute to the overall advancement of science and technology. With fewer barriers and greater resource allocation efficiency, innovation can thrive, leading to breakthroughs, advancements, and improved outcomes in various scientific and technological fields.

In summary, the paper emphasizes the contextual nature of corruption's impact on innovation, showcasing different scenarios in Nuevo Leon, Durango, and Zacatecas. It highlights the importance of tailored approaches to combat corruption based on regional dynamics. Furthermore, it underscores the potential benefits of reducing corruption, particularly in terms of minimizing transaction costs and fostering an environment conducive to scientific and technological advancements.

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ANNEXES

TABLE A1

Variable	Descripción	Fuente	Medida
Entidad	Entidad Federativa		
Police	Perception of corruption 'Very frequent' in Police	ENCIG-INEGI	percentage
Political parties	Perception of corruption 'Very frequent' in Political parties	ENCIG-INEGI	percentage
State Governments	Percepción de la corrupción "Muy frecuente" en Gobiernos Estatales	ENCIG-INEGI	percentage
Federal Governments	Perception of corruption 'Very frequent' in State Governments	ENCIG-INEGI	percentage
Chamber of Deputies and Senators	Perception of corruption 'Very frequent' in Deputies and Senators	ENCIG-INEGI	percentage
Public ministry	Perception of corruption 'Very frequent' in Public Prosecutor's Office	ENCIG-INEGI	percentage
Municipal Government	Perception of corruption 'Very frequent' in Municipal Governments	ENCIG-INEGI	percentage
Businessman	Perception of corruption 'Very frequent' among Entrepreneurs	ENCIG-INEGI	percentage
Media	Perception of corruption 'Very frequent' in Media	ENCIG-INEGI	percentage
Electoral Institutes	Perception of corruption 'Very frequent' in Electoral Institutes	ENCIG-INEGI	percentage
Judges and magistrates	Perception of corruption 'Very frequent' in Judges and Magistrates	ENCIG-INEGI	percentage
Unions	Perception of corruption 'Very frequent' in Unions	ENCIG-INEGI	percentage
Public Universities	Perception of corruption 'Very frequent' in Public Universities	ENCIG-INEGI	percentage
Public Schools	Perception of corruption 'Very frequent' in Public Schools	ENCIG-INEGI	percentage
Religious Institutions	Perception of corruption 'Very frequent' in Religious Institutions	ENCIG-INEGI	percentage
Human Rights Commissions	Perception of corruption 'Very frequent' in Human Rights Commissions	ENCIG-INEGI	percentage
Army and Navy	Perception of 'Very frequent' corruption in Army and Navy	ENCIG-INEGI	percentage
Spatentes	Patent application	IMPI	Per million inhabitants
Opatentes	Patents granted	IMPI	Per million inhabitants

TABLE A1. CONTINUATION

Sdiseños	Industrial Design application	IMPI	Per million inhabitants
Odiseños	Industrial Design granted	IMPI	Per million inhabitants
Smodelout	Utility models application	IMPI	Per million inhabitants
Omodelout	Utility models granted	IMPI	Per million inhabitants
SEP	Expenditures of SEP by federal entities	Cuenta pública federal	Expenditure per 100,000 inhabitants
N.S.R.	Researchers by the National Council of Science and Technology	CONAHCYT	Researchers per 100,000 inhabitants