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RESEARCH / INVESTIGACIÓN

Compliance with environmental standards in the manufacturing subsector of transport equipment in central western and northern regions of Mexico

Cumplimiento de normas ambientales en el subsector fabricación de equipo de transporte en las regiones centro occidente y norte de México

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Resumen: En este trabajo se analizó el cumplimiento de las normas de carácter ambiental por las unidades económicas del subsector fabricación equipo de transporte, principalmente de las ramas automotriz y aeroespacial, en las regiones centro occidente y norte de México. Los resultados, derivados de un modelo multinomial logit, demuestran que los establecimientos del grupo automotriz y aeroespacial ubicados en la región centro occidente tienen una ligera probabilidad más alta de ejecutar normas en materia de protección ambiental en comparación con los establecimientos del mismo giro industrial localizados en el norte de México. No obstante, apenas un poco más de la mitad de las unidades económicas de estas dos ramas cumplió con alguna norma de tipo ambiental. Este estudio contribuye a comprender el comportamiento ambiental, mediante el estudio del cumplimiento de normas de carácter ambiental, de dos actividades manufactureras dinámicas -automotriz y aeroespacial- en el entorno espacial donde tienen una presencia significativa como son las regiones centro occidente y norte del país.

Palabras clave: Normas ambientales, región centro occidente, región norte, industria aeroespacial, industria automotriz.

Abstract: *In this study the compliance with environmental regulations of subsector economic units of manufacture of transport equipment was carried out, mainly of the automotive and aerospace branches, inside the central and northern regions of Mexico. The results are derived from a multinomial logistic model, demonstrating that the companies of the automotive and aerospace group in the western center has a slightly higher probability of executing environmental protection regulations in comparison with the companies of the same industrial sector located in northern Mexico. However, barely more than half of the economic units of these two branches complied with any environmental standard. This study helps to understand the environmental behavior, through the study of compliance with environmental standards, of two dynamic manufacturing activities -automotive and aerospace- in the space environment where they have a significant presence such as the central and northern regions of the country.*

KeyWords: *Environmental standards, western central region, northern region, aerospace industry, automotive industry.*

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INTRODUCTION

The command and control instruments (CCIs) are commonly used by governments, with the aim that the productive agents assume productive costs of the pollution they generate. These measures to improve environmental quality are mostly mandatory and embodied in standards, laws and regulations, and their compliance is monitored by authorities through courts, fines and environmental inspectors, among others (Field & Field, 2016). The application of CCIs in certain countries, mainly developed became common in the 1970s, though in nations such as Mexico, its employment was carried out more strongly in mid-1980s and early 1990s.

CCIs generally tend to be compared with economic instruments (EIs) -taxes and environmental subsidies, negotiable emission permits, and reimbursement deposit systems- with the aim to analyze their efficiency as environmental policy, Harrington & Morgenstern (2004) point out five hypotheses in the evaluation of the two instruments:

H1: EIs are more efficient by implying a lower cost of depletion per unit of polluting emission, which is achieved when the marginal production cost equals to the social cost of the environmental damage. This advantage, theoretically implies assuming that the market structure is free competition and there is no specific location of pollutants.

H2: EIs favor the continuous incentive to reduce the emission of pollutants, which allows technological innovation for environmental care and a greater flexibility in pollution reduction goals.

H3: Regulated companies tend to oppose EIs more than CCIs due to the fear of facing the higher costs involved in their use as mechanism to reduce pollution.

H4: An advantage of CCIs over EIs is that in the first ones, the achievement of objectives is reached faster and with greater certainty.

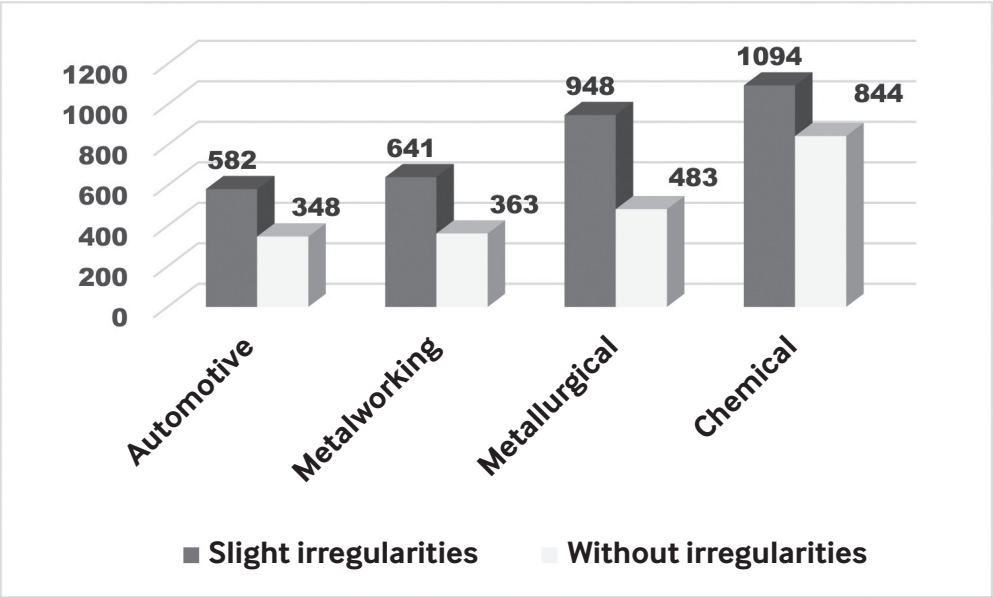
H5: In contrast, CCIs have very high administrative costs.

There are other varieties of standards that emerge from the voluntary environmental schemes, unlike CCIs that have a collective nature. This type of instruments is adopted by companies without legal ties and voluntarily. An example of this type of standard corresponds to the series of standards 14001, which are focused on environmental management activities (ISO 14001:2004 and ISO 14001:2015), and other specific aspects of environmental improving such as audits, labeling and life cycle.

In Mexico, the environmental standards designed by the Government is ruled by a set of laws, regulations and standards. Specifically, an expression of the CCIs corresponds to the Official Mexican Regulations (OMR) of the environmental sector, which are designed and created by the Secretariat of Environment and Natural Resources (SEMARNAT) and by the National Water Commission. Such standards set characteristics and specifications, criteria and procedures to protect and improve the environment and ecosystems, and preserve natural resources (Gobierno de México, 2019a). Some of these regulations directly affect a specific sector or industry, for instance the OMR.121.ECOL.1997 that establishes the maximum permissible limits for contaminants of volatile compounds that are generated in certain operations of the automotive branches (Gobierno de México, 2019b).

Another feature of the CCIs is associated with the costs of control that environmental regulations imply. In Mexico, FROFEPA performs inspections in industrial issues when a company does not comply with laws, regulations, standards and other environmental provisions. Figure 1 shows the results of the PROFEPA inspections in 2019, in four manufacturing branches: slight irregularities outweigh the non-irregularities.

Figure 1: Environmental inspections to manufacturing branches in 2019.



Source: Prepared based on SEMARNAT (2019).

In the case of voluntary environmental regulations, in Mexico the standards of environmental management ISO 14001 and the National Environmental Audit Program stand out. This program establishes a set of activities aimed at companies to perform a voluntary environmental audit. In this sense, those companies that satisfactorily cover the audit process receive some of the three certificates for two years: a) clean company certificate -manufacturing and processing activities-, b) environmental quality certificate -commercial and services (excepting tourism)-, and c) tourism environmental quality certificate -tourism activity and some related services- (Gobierno de México, 2019).

Aigner & Lloret (2013) study the environmental practices of 103 Mexican companies, placed mainly dedicated to manufacturing, transport, communication and services. An important feature of these companies is that 78.9% have more than 500 employees. In one their findings they find that around 64% of the companies interviewed considered that the compliance of environmental regulations is one of the reasons they adopt environmental practices.

A fundamental reference on the environmental performance of the companies in Mexico is the work carried out by Dasgupta et al. (2000), who conducted surveys to 236 Mexican factories. These authors state that 52% of them mentioned not to comply with any environmental regulation. However, an outstanding result of their work shows that the businesses that experienced environmental regulations such as inspections- y complied with the environmental regulations had greater degree of effort in improving their environmental performance.

Ruiz et al. (2006) link the participation of the manufacturing companies in Mexico in a voluntary program (National Environmental Audit Program) with environmental regulations. If the results of their probit model are considered where the dependent variable is equal to 1 if the company participated in the voluntary program, it has ben found that the average of legal processes (one of the independent variables) faced by the companies have a positive and statistically significant effect on the adaptation of the voluntary program.

Barajas et al. (2007) surveyed 298 executives of electronic and auto parts companies and some of their suppliers in the border cities of Tijuana, Mexicali and Ciudad Juarez. These authors group these companies according to four different levels of techno-productive complexity and use two com-

plexities -basic and intermediate advance complexity- to study environmental performance. Based on this distinction, they found that 15.6% of the companies grouped at the basic level and 12.9% of the intermediate advanced group implemented environmental protection measures, forced by the pressure of PROFEPA.

Domínguez (2006) studies environmental care strategies in four companies in Mexico, some of them with several plants. From his work it is concluded that regulation and compliance of environmental regulations are one of the main factors by which these companies employ environmental improvement actions in their businesses.

A characteristic of the studies consulted is the emphasis of the effect the compliance with environmental regulations has on the part of companies on their environmental performance. In this work, we provide a different approach when analyzing and comparing the relation of two manufacturing branches -automotive and aerospace- and their regional context with the degree of compliance of environmental regulations. These two branches have been considered due to their relevance in the creation of jobs, their integration with other economic activities and their technological development. However, given that the regional location plays a determinant role in development and consolidation of these industries (Unger, 2000), two other geographical areas were considered. In these, the economic units have a significant presence: The border region (Baja California, Sonora, Chihuahua, Coahuila, Nuevo León and Tamaulipas) and the central western region (Aguascalientes, Jalisco, Guanajuato, Querétaro, San Luis Potosí y Zacatecas).

METHODOLOGY

The statistical information was obtained from the economic from the 2014 NEGI Censuses, in particular that related to economic units of the transport equipment manufacturing subsector and their environmental module. This process implied that the sample should be made up of 1,047 productive units classified as SEG (Large business and business monitoring) by INEGI. This situation was due to the fact that the companies that were surveyed through the environmental module were from SEG. This type of business has the following characteristics (INEGI, 2014):

a) Income equal or greater than 50 million pesos, or employed personnel equal or greater than 50 people.

b) Income between 20 and 4999 million 999 thousand pesos and employed personnel of 26 to 49 people.

c) Business that are part of a national multi-business company, that is, that share a same business name and are located in more than a federative entity.

d) Local multi-business companies (all their business located in a single federative entity), with at least one economic unit that meets one of the first two parameters.

e) Economic units that are part of the National Economic Surveys.

On the other hand, the economic units of the transport equipment manufacturing were divided into three categories: 1) automotive, gathering the manufacturing branches of cars, vans and buses, bodies and trailers, parts for vehicles and automobiles; 2) aerospace; and 3) other transport equipment integrated by the branches of railway equipment, boats and others.

Regarding the regions, the entities with significant presence of companies of the transport equipment manufacturing center were taken into account. For this reason, the group was determined in the northern region: Baja California, Sonora, Chihuahua, Coahuila, Nuevo León and Tamaulipas; and central western region: Aguascalientes, Jalisco, Guanajuato, Querétaro, San Luis Potosí and Zacatecas.

The analysis instrument to study the compliance of environmental regulations by transport equipment manufacturing companies in the northern and central western regions of Mexico was through a logit multinomial model. Both development and application of this model was based on Gujarati (2013), when

$Y_{ij} = 1$, if the economic unit *i* of some of the branches of the transport equipment manufacturing subsector chose the option j when asked if the company met some envi-

ronmental regulation. In this case, $j = 1$ when the answer was yes, $j = 2$ when the answer was no, and $j = 3$ when there is no answer. On the other hand, $Y_{ij} = 0$ otherwise.

$X_1 = 1$ if the economic unit is grouped in the automotive Branch and 0, otherwise.

$X_2 = 1$ if the productive unit belongs to the aerospace Branch and =, otherwise.

$X_3 = 1$ if the business belongs to the transport equipment manufacturing subsector is located in the central western region.

$X_4 = 1$ if the company of the transport equipment manufacturing subsector is located in the northern region.

Based on these variables, the logit multinomial probabilistic model is described as follows:

$$\theta_{ij} = \Pr(Y_{ij} = 1) = \frac{e^{\alpha_j + \beta_j X_i}}{\sum_{j=1}^{3} e^{\alpha_j + \beta_j X_i}} \quad (1)$$

Where Pr is referred to the probability, subindex j (some of three choices) accompanies the intercept (β) and the slope coefficient (α). Xi represents the set of four variables mentioned above, so that there are four slope coefficients that differ according to the alternative chosen. Thus, the three probabilities imply different coefficients for the independent variables, resulting in the estimation of three regressions. However, it should be noted that the three probabilities entail θi1 + θi2 + θi3 = 1. Therefore, the probabilities can be estimated independently. The procedure consisted in choosing a base or comparison alternative. In this work, the answer that was taken as comparison reference was when the economic unit replied that no environmental regulation was followed (j =2). Consequently, the estimation of the probabilities of the three elections was derived by the following equations:

$$\theta_{i1} = \frac{e^{(\alpha_1 + \beta_{11}X_1 + \beta_{12}X_2 + \beta_{13}X_3 + \beta_{14}X_4)}}{1 + e^{(\alpha_1 + \beta_{11}X_1 + \beta_{12}X_2 + \beta_{13}X_3 + \beta_{14}X_4)} + e^{(\alpha_3 + \beta_{31}X_1 + \beta_{23}X_2 + \beta_{33}X_3 + \beta_{34}X_4)}} \quad (2)$$

$$\theta_{i2} = \frac{1}{1 + e^{(\alpha_1 + \beta_{11}X_1 + \beta_{12}X_2 + \beta_{13}X_3 + \beta_{14}X_4)} + e^{(\alpha_3 + \beta_{31}X_1 + \beta_{23}X_2 + \beta_{33}X_3 + \beta_{34}X_4)}} \quad (3)$$

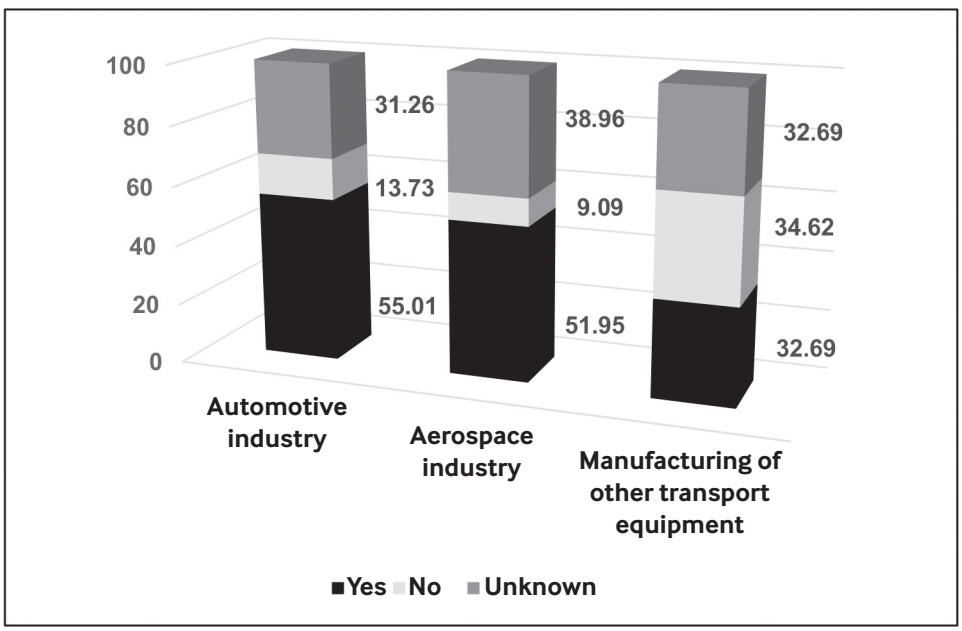
$$\theta_{i3} = \frac{e^{(\alpha_3 + \beta_{31}X_1 + \beta_{32}X_2 + \beta_{33}X_3 + \beta_{34}X_4)}}{1 + e^{(\alpha_1 + \beta_{11}X_1 + \beta_{12}X_2 + \beta_{13}X_3 + \beta_{14}X_4)} + e^{(\alpha_3 + \beta_{31}X_1 + \beta_{23}X_2 + \beta_{33}X_3 + \beta_{34}X_4)}} \quad (4)$$

RESULTS

In the econometric estimation of equations (2), (3) and (4), the maximum likelihood method was used. A simple way to interpret the coefficients, pot example, is to calculate what is the probability that the economic units comply with some regulation in terms of environmental protection, given that hey belong to a certain group of activity (automotive, aerospace or other transport equipment) and are located in certain region (northern or central western).

Figure 2 shows the participation of economic units within the group in which they were cataloged, and responded to the questioning if they met any environmental regulation. It should be noted that a little more than half of the productive units of the automotive and aerospace branches expressed a positive response. It is noteworthy that the remaining businesses -very close to half- declared not knowing or not executing any environmental regulation.

Figure 2: Compliance with some environmental regulation of the manufacturing subsector of transport equipment.



Source: own based on INEGI (2019).

Table 1 shows the results of equations (2), (3) and (4) through the logit multinomial method. As stated by Wooldrige (2003), the magnitude of the coefficients is difficult to interpret. However, tehere are alternate ways to analyze the products of these econometric estimations. An option consisted in calculating the probabilities under different scenarios, for example, the probability that an economic unit of the aerospace branch located in the central western region will respond that if it complied with any environmental regulation, this value was 0.56. On the other hand, a unit of the same productive branch located in the northern region has a probability of 0,52 (Table 2), that is, an economic unit of the aerospace activity in the central western region has a 0-04 higher possibility. Compared with another one in the northern area of complying with some environmental regulation.

Table 1: Results of the multinomial logit regression of equations (2), (3) and (4).

Dependent variable: complied with some environmental regulation		
Explanatory variables	Yes	Unknown
Automotive branch	1.34*	0.80*
	0.360	0.360
Aerospace branch	1.53*	1.24*
	0.540	0.550
Central western region	0.300	0.002
	0.250	0.270
Northern region	0.57*	0.55*
	0.220	0.240
Constant	-0.280	-0.230
	0.350	0.350

*significativa al 5 %

Table 2: Calculation of probabilities with some environmental regulation of the economic units of the aerospace branch.

Dependent variable: Yes, it complied with some environmental regulation (aerospace branch)

Explanatory variables	Yes (1)	Aerospace, central western (2)	Aerospace, north (3)	(1) x (2)	(1) x (3)
Automotive branch	1.34	0.00	0.00	0.00	0.00
Aerospace branch	1.53	1.00	1.00	1.53	1.53
Central western region	0.30	1.00	0.00	0.30	0.00
Northern region	0.57	0.00	1.00	0.00	0.57
Constant	-0.28	1.00	1.00	-0.28	-0.28
Summation	—	—	—	1.55	1.82
Probability	—	—	—	0.56	0.52

Following a similar process, if we compare a business of aerospace nature of the central western region with one in the northern region, the first one has a 0.073 lower probability of indicating that it does not know if some environmental regulations was applied (Table 3). From previous data it should be noted that the difference in the probability of not complying with environmental regulations is 0-03 higher for an economic unit of aerospace branch of the central western region.

Table 3: Calculation of probabilities of ignorance of some environmental regulation of the economic units of the aerospace branch.

Dependent variable: It is unknown if some environmental regulation was met (aerospace branch)

Explanatory variables	**Unknown (1)**	**Aerospace, central western (2)**	**Aerospace, north (3)**	**(1) x (2)**	**(1) x (3)**
Automotive branch	0.800	0.00	0.00	0.000	0.000
Aerospace branch	1.240	1.00	1.00	1.240	1.240
Central western region	0.002	1.00	0.00	0.002	0.000
Northern region	0.550	0.00	1.00	0.000	0.550
Constant	-0.230	1.00	1.00	-0.230	-0.230
Summation	—	—	—	1.012	1.560
Probability	—	—	—	0.325	0.398

In the case of the branches of the automotive group, a company in the central western region linked to this productive activity presents a 0.02 higher probability of adopting environmental regulations than a company of the same branch located in the northern region (Table 4). On the other hand, the probability of ignoring compliance of some environmental regulation is 0.069 lower than the economic units located in the central western region of Mexico (Table 5). Likewise, it is deduced that a company of the automotive branch of the central western region has a 0.04 higher probability of not performing any environmental regulation.

Table 4: Calculation of probabilities of compliance of some environmental regulation of the economic units of the automotive branch.

Dependent variable: If complied with some environmental regulation (automotive group branch).

Explanatory variables	Unknown (1)	Automotive, central western (2)	Automotive, north (3)	(1) x (2)	(1) x (3)
Automotive branch	1.34	1.00	1.00	1.34	1.34
Aerospace branch	1.53	0.00	0.00	0.00	0.00
Central western region	0.30	1.00	0.00	0.30	0.00
Northern region	0.57	0.00	1.00	0.00	0.57
Constant	-0.28	1.00	1.00	-0.28	-0.28
Summation	—	—	—	1.36	1.63
Probability	—	—	—	0.58	0.56

Table 5: Calculation of probabilities of ignorance of some environmental regulation of the economic units of the automotive branch.

Dependent variable: It is unknown if some environmental regulation was met (automotive group branch).

Explanatory variables	Unknown (1)	Automotive, central western (2)	Automotive, north (3)	(1) x (2)	(1) x (3)
Automotive branch	0.800	1.00	1.00	0.800	0.800
Aerospace branch	1.240	0.00	0.00	0.000	0.000
Central western region	0.002	1.00	0.00	0.002	0.000
Northern region	0.550	0.00	1.00	0.000	0.550
Constant	-0.230	1.00	1.00	-0.230	-0.230
Summation	—	—	—	0.572	1.120
Probability	—	—	—	0.265	0.334

From the results it can be observed that the practice of mandatory or voluntary environmental regulations is not generalized by the economic units of the transport equipment manufacturing subsector. This aspect is reinforced, as observed in Figure 2, by the fact that a little more than half of the companies of the automotive and aerospace groups recognized that adopted some environmental regulation. On the other hand, it is shown that that there is a slightly higher probability that the productive units of the central western region apply environmental regulations compared to those located in the northern region. Perhaps this aspect is explained by the lower regional dispersion in which the companies of this subsector are placed in the federative entities of the central western region. For example, in the automotive activity, the region of bajío -Querétaro, Guanajuato, Aguascalientes and San Luis Potosí there is an important group of automotive companies that have consolidated a dynamic and innovative cluster.

However, the fact that almost half of the companies of the transport equipment manufacturing subsector fail in complying with certain environmental regulations is not assumed that these instruments are ineffective or do not encourage innovation in this type of organizations. In fact, a possible line of future research involves studying whether environmental regulations help companies in Mexico being

motivated to seek technical and administrative innovations that decrease the costs of reducing air, water and soil pollutants generated in the production of goods and services.

CONCLUSIONS

In this work, the probability of response of the economic units of the economic units in the transport equipment manufacturing subsector that comply with some environmental regulations in the context of two geographical areas where these companies have a significant weight and influence on technological development and economic growth are the central western and northern region. Data from the study came from the 2014 economic censuses, related to the transport equipment manufacturing subsector and the environmental module. This resulted in sample of 1,047 companies of the SEG group (Large companies and business monitoring). The companies were classified in automotive -considered branches related to this activity- aerospace and others transport equipment. To estimate the probability the logit multilinear regression model was used. This model is related as a dependent variable of the three types of response referred with the adoption of environmental standards: 1 = complied, 2= not complied, and 3= unknown. The dichotomic dependent variables are linked to the aerospace and automotive groups and central western and northern regions.

The findings show that the companies of the automotive and aerospace group of entities in the central western and northern region are slightly more likely to comply with environmental regulations, opposed to the economic activities of the same productive activities in the northern region. However, in absolute terms, a little more than half of the economic units in the sample belonging to these two productive branches expressed that they apply some environmental regulations. It is significant that around 32% and 39% of the companies classified as automotive and aerospace, respectively mentioned ignoring that they obey certain environmental regulations. Our work only exhibits the decisions made by the companies of the transport equipment manufacturing subsector in relation to the adoption of environmental regulations since they offer no evidence about their effectiveness in reducing pollutant emissions or incentives for companies in this sector make innovations that imply the use of productive and administrative techniques towards a cleaner environment.

A line of future research consists in testing the hypothesis that environmental regulations specifically, coercive or voluntary in terms of environmental protection imply a boost for companies in this subsector or other economic activities to trigger technological and administrative innovations that entail a reduction in cost of depletion of pollutant they generate.

Finnaly, this work contributes to offer evidence about the degree of compliance with environmental regulations

Of two dynamic and manufacturing branches relevant for national and local economy, as is the case of the automotive and aerospace activity. In addition, the wide scope it has in terms of the number of economic units of the sample (1.047) and the geographical amplitude covering two regions where the branches have a significant presence and weight in the local economic activity.

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