Patents and Articles Related to Cooperation in Universities, Using Poisson Regression Models

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Abstract

University-industry cooperation is the formation of partnership relationships that exist in Science and Technology Institutions with industries, that is, it is the cooperation that exists between universities and industries. In this sense, there are several ways of forming relations between universities and industry, and for this to happen, it all boils down to cooperation, since both agents need to agree with certain achievements, there must be communication between them. Despite all the existing benefits, even if there is reciprocity between these agents that seek a common denominator, there are still divergences that remain as a difficulty factor for this cooperation, since there are several differences found in the academic and industrial environment. Thus, we sought to analyze how are the production of articles aimed at university-industry cooperation, as well as patents related to this subject, through specific bases. A forecast analysis was also carried out using the Poisson Regression models, where it was found, in the data of patents and articles, a superdispersion, therefore, it was necessary to adjust the deviation G ^ 2 or as known deviance, and with the adjustment of overdispersion the models were adequate and confirmed in the forecast made. We thank Capes and CNPq for their support and financial support.

Keywords: University-industry; Cooperation; Regression Poisson Models

1. Introduction

The existing cooperation in the university-industry triggered as a primordial phenomenon with respect to the focus of several studies that have been taking place over the years. Therefore, this relationship of mutual support concerns the interaction between the higher education system and the industries, whose main objective of universities is to promote the transfer of knowledge and consequently the technologies resulting from technological development projects (ANKRAH; AL-TABAA, 2015 apud RUSSO et al, 2017).

Interaction within universities and industries plays a significant role in technological innovation, since it contributes to the economic growth of countries, and currently the results for the development of countries and organizations are relevant, as well as scientific production on this topic has increased (ROSA et al., 2018). This interaction represents a fundamental factor for technological development, innovation and entrepreneurship (ALMEILDA, 2019).

There is a new scenario in which the university begins to acquire a new role in its mission, since the commercialization of knowledge that is produced at the university contributes significantly to improvements in the industries, in this sense it leads to local and regional development, through technological innovation, however, even with the existing conservative objectives, it is still possible to observe that there is a priority to focus on teaching and research, however the transfer of knowledge to industry is still something new for universities.

The contribution of this work is to analyze scientific production through articles and technological production, as well as through university-industry cooperation patents at the bases, using a statistical technique, Poisson regression model.

For Bockenholt (1999) a set of discrete data in which the response variable cannot be transformed into a normal distribution, these data are more difficult to analyze. Many studies have been concerned with finding the regularity of the data, assuming it is a Poisson process and are often analyzed using Poisson regression models.

The Poisson Regression models do not take into account a possible dependence between the observations, however, for data collected over time it is necessary to take into account the dependence between the observations, in order to obtain a correct statistical analysis (ZEGER; LIANG, 1986).

The research aims to understand the existing cooperation between university and industry, and in this sense to analyze patents as well as the production of articles focused on the theme, using the Poisson model, to consolidate the results of this study.

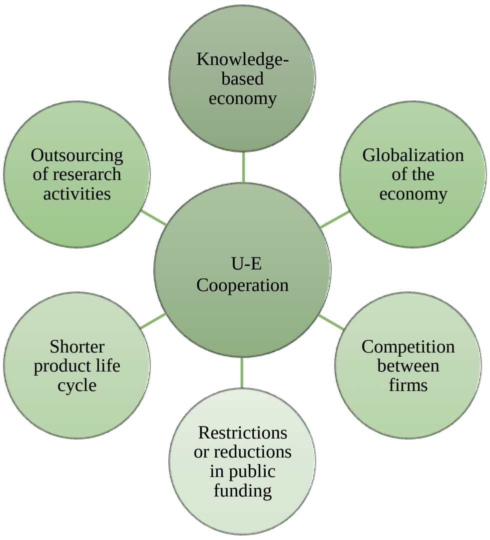
2. Theoretical Foundation

2.1 Cooperation with a focus on University-industry

At the university there is the development of basic research, while in industry there is applied research, however for this interaction to occur there are some challenges, but for scientific research not to be only at universities they must be transferred so that society can have access to knowledge (AGUSTINHO; GARCIA, 2018). And, the technology transfer process allows the construction of a partnership relationship between the offerer and the receiver, so that both benefit (DIAS; PORTO, 2014).

According to Gusmão (2002) there are several factors that favor the existence of the cooperation process, and among these there are those that stand out as inducers for university-industry cooperation, this can be seen in Figure 1.

Figure 1 - Induction factors for university-industry cooperation



Source: Elaborated by the authors based on Gusmão (2002)

On the other hand, Perkmann et al. (2011) apud Russo et al (2017), complement that there are five specific forms of relationships established between universities and industries, that is, joint and / or collaborative research, contracted, consulting, licensing, and finally academic entrepreneurship. And each of these forms of relationship can be seen in Figure 2, explicitly.

Figure 2 - Forms of the relationship between university and industry

Source: Prepared by the authors based on Perkmann et al. (2011); Bercovitz and Feldman (2006); Mansfield (1995) and Russo et al (2017).

In this sense, university-industry cooperation arises, where it generates benefits for industries and universities, with the process of transferring technology from universities, there is the promotion of innovation, and for universities the transfer of technology allows obtaining resources that allow for an increase development of scientific research (ETZKOWITZ, 2004).

Authors such as Santana and Porto (2009) complement that the cooperation between universities and industries generates benefits not only for agents directly involved in the interaction, but for the whole country, as it improves industrial, regional and local competitiveness, and for all these agents involved in the process are able to have their needs met, it is necessary that policies at the university level are not an impediment to make this cooperation model effective.

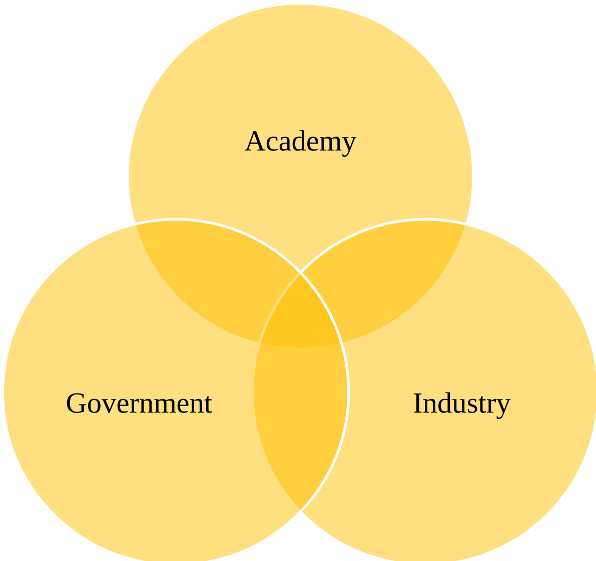
In this regard Santana and Porto (2009) explain that initially, the relations of university-industry cooperation were based only on the sponsorship of industries for research carried out in universities, however there was an evolution in the cooperation process that at the university level revolutions arose academic.

Garnica (2007) describes that the results of research carried out in universities if protected have become intellectual property, that is, it becomes a good with which it can be commercialized, through the possibility of transferring the intellectual property produced in universities to the productive sector. , where there is collaboration with the economy.

To explain the model of the triple helix Etzkowitz and Leydesdorff (2004) affirm that it is one of the most referenced in relation to the different agents of the process of innovation, technology transfer and university-industry cooperation.

Figure 3 presents the Triple Helix model, where it characterizes the connections of three segments, being universities, industries and the government, where together they lead to favorable environments for technological innovation.

Figure 3 - Triple Helix Model



Source: Adapted from Etzkowitz and Leydesdorff (1997) apud Miranda; Santos; Russian (2017).

2.2.1 Existing challenges in cooperation and technology transfer in the university-industry category

There is a need for innovation to be disseminated through academic entrepreneurship, to strengthen the interaction between universities and industries, where research on cooperation models is necessary (TATUM et al, 2018; SANTOS, BENNEWORTH, 2019).

Even with all the benefits present in university-industry cooperation, Santos, Toledo and Lotufo (2009) report that the relationships are complex and sensitive, because for the process to work, industries must be prepared to relate to the university, where there should be interest in both parties.

The transfer of technology and cooperation between universities and industries presents obstacles due to the need for qualified labor (GARNICA, 2007).

Finally, the result of the failures and lack of communication between the productive sector and the research institutions is still the main difficulty encountered in carrying out the technology transfer process in the sense of the university-industry, since most of the challenges and / or difficulties encountered in this context is summed up in the absence of a culture of cooperation between both involved.

3. Poisson´s Regression Models

The Poisson Regression models were introduced by Nelder and Wedderburn in 1972, they are a useful alternative to the traditional methods of data analysis that require transformations (Russo, 2002), being a specific type of the Generalized Linear Models (MLG).

The response variable of a Poisson regression must follow a Poisson distribution and the data must have equal dispersion, that is, the average of the response variable must be equal to the variance. However, when working with experimental data, this property is often violated. Thus, one can have an overdispersion when the variance is greater than the average; or a sub-dispersion when the variance is less than the average. In these cases, it is still possible to apply the Poisson Regression model by making some adjustments (TADANO, et al. 2009).

Next, the Poisson distribution will be described and then the development of a Poisson regression model for the analysis of discrete series over time will be presented.

3.1 Poisson distribution

According to Russo (2002), the Poisson distribution is a discrete probability distribution, applicable to the occurrence of an event at a specified interval, it is the main reference for the analysis of count data and its probability function is presented below.

Let Y be a random variable with Poisson distribution, denoted by Y ~ P (λ), where parameter $\lambda > 0$. Then the probability function of Y is given by:

$$P(Y=y) = \frac{e^{-\lambda}\lambda^{y}}{y!}, \quad y = 0,1,2,3,... \ \lambda > 0$$

If the events under counting occur independently and subject to a constant rate $\lambda > 0$, under the Poisson model, for an exposure interval of size t we have:

$$P(Y_t = k) = \frac{e^{-\lambda t}(\lambda t)^{k}}{k!}, \quad k = \quad 0,1,2,3,...$$

Among the main properties of the Poisson distribution, there are: Following the following properties (adapted from ZEVIANI; JÚNIOR and TACONELI, 2016):

1 - Mean: E (Y) = λ

2 - Variance: Var (Y) = λ;

3 - Successive probability ratio: (P (Y = y)) / (P (Y = y-1)) = (λ) / k, generating the recurrence ratio: P (Y = y) y = P (Y = y −1) λ;

4 - If Y_1, Y_2, ..., Y_n are v.a.s independent with Y ~ P (λ), and ∑λ_i <∞, then ∑Y_i ~ Poisson (∑λ_i).

3.1.1 Poisson Regression Model

Ender (2002) apud Russo (2002) states that in the last 20 years interest in the study of analysis of count data has grown. According to Russo (2002), after the logistic regression, the Poisson regression model is the most used of the Generalized Linear Models (MLG) and are applied when the answer is a count, such as the number of events occurred in a space of time.

Kroll (2018) mentions that the Poisson regression model is the most natural example of a counting data regression model, and when models with counting data response include models based on the negative binomial distribution they can deal with an overdispersion of the data.

These are useful for traditional methods of data analysis that need transformations, that is, to improve experiments in different fields that involve variables and do not have a normal distribution, MLG generalize the traditional model of linear normal regression, creating options for the distribution of the response variable and generating greater flexibility in the connection between the mean and the systematic part of the model (PAULA, 1997 apud RUSSO 2002).

The MLG is written as follows (NELDER, WEDDERBURN, 1972; TAKAHASHI, KUROSAWA, 2016):

$$g\big(E(Y|X)\big) = \alpha + \beta^T X; Y|X \sim P(\theta)$$

where α is the intercept, it is the coefficient, T the time, X and Y independent variables and P (θ) a distribution of the exponential family of parameter θ.

Therefore, the Poisson regression model is given by:

$$Log\big(E(Y|X)\big) = \alpha + \beta^T X; Y|X \sim P(\theta)$$

onde $Y|X \sim P(\theta)$, então

$$E(Y|X) = Var(Y|X) = \exp(\alpha + \beta^T X)$$

To perform the adjustment of the Poisson regression model, it is common to have as a basis the maximum likelihood estimation method, a method where the estimators are obtained from maximizing the likelihood function (BOLFARINE; SANDOVAL, 2001).

According to Cordeiro (1992) apud Russo (2002), the Poisson regression model is a specific GLM that is used to estimate the model's parameters using the Maximum Likelihood method. The Likelihood Function is expressed by:

$$L = \prod_{i=1}^{n} \Pr(\frac{Y_i}{\lambda_i}) = \prod_{i=1}^{n} \frac{e^{-\lambda_i}.\lambda_i^Z}{Y_i!}$$

and its Log-Likelihood function is equivalent to:

$$\log L = \sum_{i=1}^{n} [-\lambda_i + Y_i \log(\lambda_i) - \log(\lambda_i)]$$

$$\log L = \sum_{i=1}^{n} (Y_i\,.\log(\lambda_i) - \lambda_i)$$

Schafer (1997) states that the statistic that serves to compare the significance of the adjusted and saturated models of the likelihood ratio test is given by the adjustment of the model evaluated through the G ^ 2 deviation.

$$G^2 = -2\log\left[\frac{L(modelo\ com\ variável)}{L(modelo\ saturado)}\right] \cap \chi^2_{n-p}$$

For the model without significant variables, this is given by:

$$G^2 = -2\log\left[\frac{L(modelo\ sem\ variável)}{L(modelo\ saturado)}\right] \cap \chi^2_{n-p}$$

Used to verify the quality of the fit for the Poisson regression model, the G ^ 2 deviation admits the following equation:

$$G^2 = 2\sum_{i=1}^{n}\left(y_i\left(\frac{y_i}{\widehat{\lambda_i}}\right) - (y_i - \widehat{\lambda_i})\right)$$

Complemented by Pearson's Chi-Square test, the equations together serve to verify the quality of the fit of the model represented by:

$$\chi^2 = \sum_{i=1}^{n}\frac{(y_i - \widehat{\lambda_i})^2}{\widehat{\lambda_i}}$$

According to Coxe et al. (2009), for the Poisson regression model, the percentage of reduced G ^ 2 can be calculated, that is, its variability through:

$$\left(1 - \frac{G^2\ (Modelo\ ajustado)}{G^2\ (Modelo\ nulo)}\right).10$$

4. Methodology

The methodology used in this study was characterized as exploratory research of a quantitative character. For Boente and Braga (2004) exploratory research is characterized by an investigation of a study that presents little information. In the same sense, Vergara (2007, p. 47) states that exploratory research should not be confused with exploratory research, as it is carried out in an area for which there is little accumulated knowledge.

Richardson (1999) approached that, the quantitative research is characterized by quantifying the data in the collection of the research information, and in this way, statistical techniques are used.

For data collection and analysis, two bases were chosen, the International patent search base, Espacenet, which belongs to the European Patent Office, and the Scopus database belonging to the Elsevier group, which is a database of abstracts, citations from articles for academic newspapers and/or magazines.

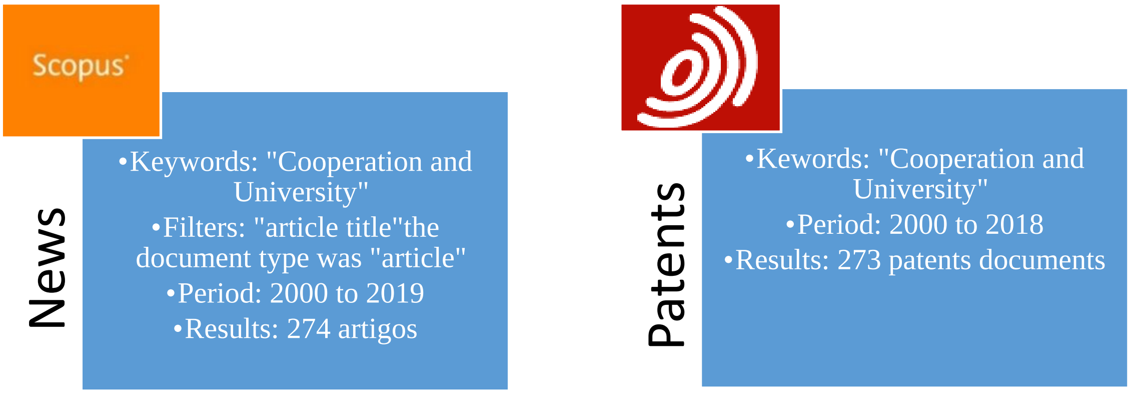
For the present study, as it presents a more complete database in its base and presents journals with a large impact factor, the database selected for the research was Scopus for search of articles and the Espacenet database, which belongs to the Office European patent search for patents.

The first research was carried out with the terms "Cooperation and University", which resulted in 274 articles, filters were applied restricting these publications to "article title", the type of document was "article" in the period from 2000 to 2019.

In the search for patent documents, the keywords used in "Cooperation and University" were used in the title and summary field in order to find patent documents related to the study. 273 patent documents were found, between the years 2000 to 2018. The period ended in 2018 is justified for putting the research data still confidential to searches in the public domain.

Therefore, the figure below shows the procedures used to search for articles and patents, figure 4.

Figure 4 - Procedure for analyzing the article search and patent filings



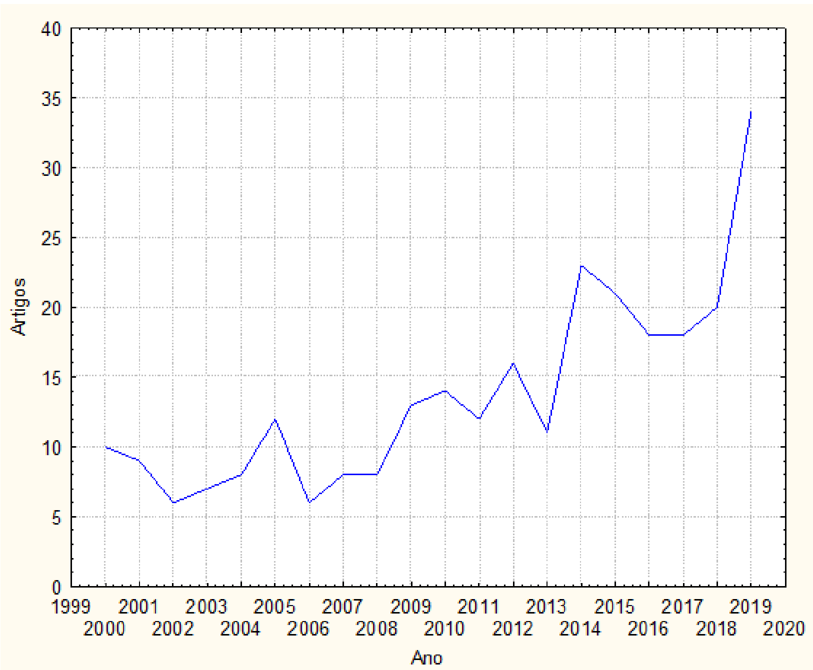
Source: Elaborated by the authors (2020)

5. Analysis and discussion of results

5.1 Analysis of the Poisson Regression Model - Articles

The series shown in figure 5 refers to the search for articles in the Scopus database in the annual period from 2000 to 2019 using the keyword cooperation and University and filters restricted to article title and type of document article, of which 274 articles are exposed based on the search.

Figure 5 - Annual evolution of articles 2000 – 2019



Source: Elaborated by the authors (2020)

Through Figure 5, it is possible to observe that the data have a randomness in the evolution of articles in the period from 2000 to 2019. The data, apparently, have a trend over the number of articles, which we will confirm by checking the Poisson Regression Model. observing whether the Deviance Scale and Pearson Scale are suitable for the model based on their Degrees of Freedom.

Table 1 shows the descriptive records of the variation and deviation related to the articles, as well as other measures:

Table 1: Descriptive Statistics

Value n	Average	Median	Fashion	Mín	Max	Var	Detour	Coef. Var
274	13,7	12	8	6	34	49,69	7,05	51,46%

Source: Elaborated by the authors (2020)

Table 1 shows an average of 13.7 articles, with a minimum and maximum value of 6 and 34 articles, respectively. The data variation was 49.69 articles and a deviation of 7.05 articles. The coefficient of variation in the number of articles was 51.46%, showing a high variation in the data.

5.1.1 Poisson Regression Models – Articles

Table 2 indicates the parameters of the Poisson Regression mode

Table 2: Summary of model parameters

	Coef	Standard Error (SE)	Coef (SE)	P-value
Z	-145,51	22,22	42,88	0

Source: Elaborated by the authors (2020)

The Poisson Regression model was:

$$Z = -145{,}51 + \text{erro}$$
$$(22{,}21)$$

Table 3 shows the criteria for evaluating these articles through modeling in the Poisson Regression Models.

Table 5: Criteria for evaluating the model

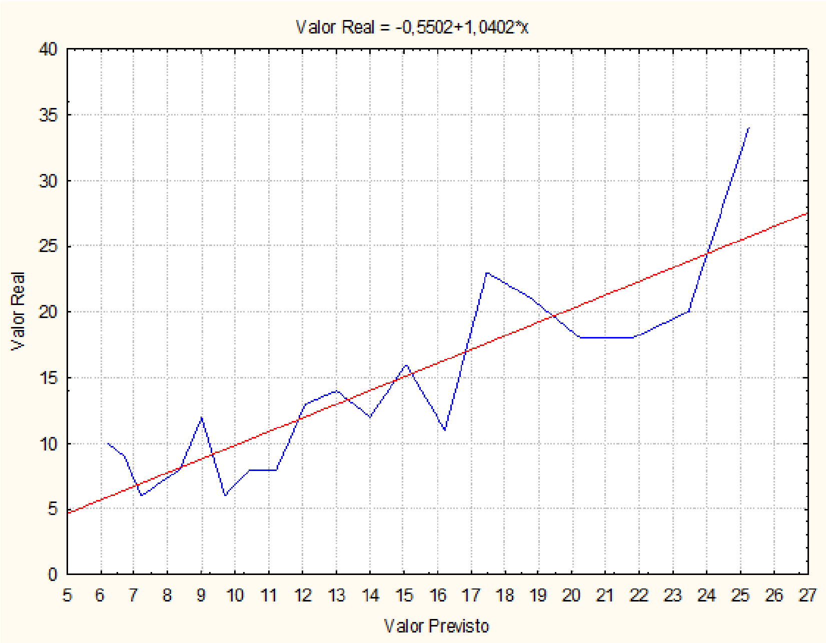
Criteria	Dregress of freedom	Values	Values/GL
Climing "Deviance" (G^2)	18	18	1
Scale of (X^2)	18	18,35	1,02
Likelihood		32,38	

Source: Elaborated by the authors (2020)

As the Pearson's G ^ 2 and Chi-Square Statistics in Table 5 of the model approach 1, then the Poisson regression model is adequate.

Figure 6 shows the short-term forecast of the model, once again demonstrating that the model is adequate. The forecast was growing, as the months went by.

Figure 6 - Representative of Forecasts



Source: Elaborated by the authors (2020)

After confirming the model in question, short-term forecasting is now performed using values from the series that were considered out of the ordinary. Table 6 shows the actual and expected values of the model:

Table 6: Short-term forecast

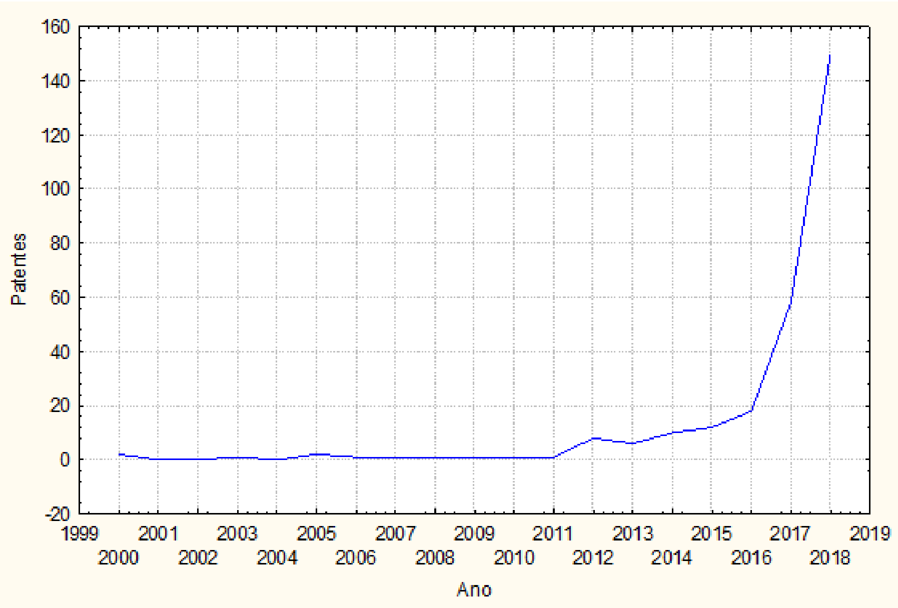
Real Value	Pred. Value	Linear Pred.
6	7,22	1,98
7	7,77	2,05
8	8,36	2,12
13	12,08	2,49
14	13,01	2,57
16	15,07	2,71
18	20,24	3,01
20	23,45	3,15

Source: Elaborated by the authors (2020)

5.2 Analysis of the Poisson Regression Model – Patents

The series shown in Figure 7 has as a reference the search for patents on the espacenet basis in the annual period from 2000 to 2018. This presented a total of 273 patents based on the search. As the search data is not yet available in the public domain, 2019 will not be included in the study.

Figure 7 - Annual evolution of patents 2000 – 2018



Source: Elaborated by the authors (2020)

From Figure 7, it is possible to observe that the data have a randomness in the evolution of patents in the period from 2000 to 2018. The data, apparently, have a trend over the number of patents, which we will confirm by checking the Poisson Regression Model. observing whether the Deviance Scale and Pearson Scale are suitable for the model based on their Degrees of Freedom.

Table 7 shows the descriptive records of the variation and deviation related to patents, as well as other measures:

Table 7: Descriptive Statistics

Value n	**Average**	**Median**	**Fashion**	**Mín**	**Max**	**Var**	**Detour P.**	**Coef. Var**
273	14,37	1	1	0	150	1256,91	35,45	246,74

Source: Elaborated by the authors (2020)

Table 7 shows an average of 14.37 patents, with a minimum and maximum value of 0 and 150 patents, respectively. The variation in the data was 1256.91 patents and deviation of 35.45 patents. The coefficient of variation in the number of patents was 246.74%, demonstrating a high variation in the data.

5.2.1 Poisson Regression Models – Patents

Table 8 indicates the parameters of the Poisson Regression model.

Table 8: Summary of model parameters

	Coef	Standard Error (SE)	Coef (SE)	P-value
Z	-1082,99	66,71	263,52	0

Source: Elaborated by the authors (2020)

The Poisson Regression model was:

$$Z = -1082{,}99 + erro$$
$$(66{,}71)$$

Table 9 shows the evaluation criteria for these articles through modeling in the Poisson Regression Models.

Table 9: Criteria for evaluating the model

Criteria	**Degress of freedom**	**Values**	**Values/GL**
Climbing "Deviance" (G^2)	17	71,27	4,19
Climbing Pearson (X^2)	17	672,23	39,55
Likelihood		-54,30	

Source: Elaborated by the authors (2020)

Table 9 shows that the "Deviance" Scale and the Pearson Scale are not suitable for the model, because their Degrees of Freedom are not equal to or close to 1. Therefore, data overdispersion should be analyzed. Table 10 shows the parameters of the overdispersion, which is used to improve the model.

Table 10: Summary of model parameters

	Coef	**Standard Error (SE)**	**Coef (SE)**	**P-value**
Z	-1082,99	419,53	6,66	0,009839

Source: Elaborated by the authors (2020)

The Poisson Regression model was:

$$Z = -1082{,}99 + erro$$
$$(419{,}53)$$

Table 11 shows the criteria for evaluating these patents for λ if the model is adequate by applying the G ^ 2 test and Pearson's chi-square test.

Table 11: Criteria for evaluating the model

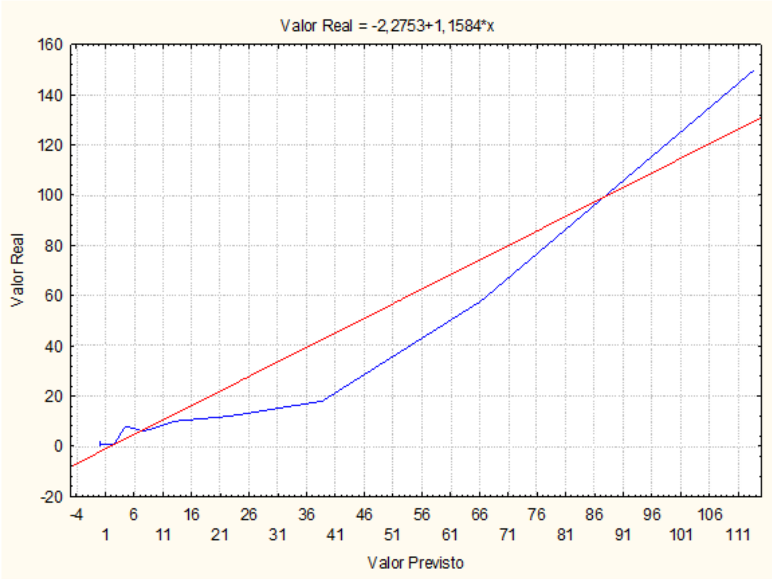
Criteria	**Degress of freedom**	**Values**	**Values/GL**
Climbing "Deviance" (G^2)	17	1,80	0,11
Climbing Pearson (X^2)	17	17,00	1
Likelihood		-847,22	

Source: Elaborated by the authors (2020)

As the Pearson's G ^ 2 and Chi-Square Statistics in Table 11 of the model approach 1, then the Poisson regression model is adequate.

Figure 8 shows the model's short-term forecast, showing a forecast demonstrated once again that the model is adequate. The forecast was growing, as the months went by.

Figure 8 - Representative of Forecasts



Source: Elaborated by the authors (2020)

After confirming the model in question, the short-term forecast is now performed, using values from the series that were considered out of the ordinary. Table 12 shows the actual and expected values of the model:

Table 12: Short-term forecast

Real Value	Pred. Value	Linear Pred.
1	1,53	0,42
1	2,61	0,96
6	7,68	2,04
10	13,17	2,58
12	22,58	3,12
18	38,71	3,66
58	66,36	4,20
150	113,76	4,73

Source: Elaborated by the authors (2020)

6. Conclusion

In this article, an analysis of the scientific production of articles and technological production was carried out through the patents of university-industry cooperation based on a statistical technique called the Poisson regression model, in order to understand the existing cooperation between universities and industry, using the Poisson model, to consolidate the results of this study.

The methodology of this study was an exploratory research of quantitative character, for the collection and analysis of the data the International basis for patent search was chosen called Espacenet, which belongs to the European Patent Office, and the SciVerse Scopus base belonging to the Elsevier group that is a database of abstracts, citations of articles for newspapers and / or academic journals.

The first research was carried out with the terms “Cooperation and University”, which resulted in 274 articles and filters were applied, restricting these publications to “article title”. The type of document was “article” in the period from 2000 to 2019. In the search for patent documents, the keywords “Cooperation and University” were used in the title and summary field in order to find patent documents related to the study, resulting in in 273 patent documents between the years 2000 to 2018.

A evolução anual de depósitos nas bases estudadas apresentou oscilações, o que tornou adequado a aplicação do modelo de regressão de Poisson. Após a aplicação desta modelagem nas duas buscas, a Escala de “Deviance” e a Escala de Pearson não se mostraram adequados para o modelo devido seus Graus de Liberdade não serem igual ou próximos de 1, sendo necessário a realização da análise da superdispersão dos dados, usado para melhorar o modelo. Realizado o ajuste do desvio G^2 (*deviance*) com o ajuste da superdispersão, os modelos apresentaram-se adequados para a análise, onde é confirmado na previsão realizada.

7. Acknowledgement

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