# Analysis of tobacco productivity in Mexico between 1980 and 2020 through the KLEMS methodology

**Revilla-Chaviano, Alejandro[1]; Soca-Cabrera, José Ramón[2]; Chaviano-Rodríguez, Nadia Rosa[3]; Luquez-Gaitan, Carlos Ernesto[1*]**

[1] Universidad Politécnica de Texcoco, Carretera Federal los Reyes - Texcoco 14.200 San Miguel Coatlinchan, 56250 Texcoco, México.
[2] Universidad Autónoma Chapingo Carretera Federal los Reyes - Texcoco 14.200 San Miguel Coatlinchan, 56250 Texcoco, México.
[3] Investigador independiente.
* Correspondence: carlosluquezgaitan@gmail.com

**ABSTRACT**

**Objective**: Tobacco production experienced a gradual growth during the first half of the 20th century, but its increase has been truncated in the last four decades. The objective of the study is to analyze the productivity of tobacco in Mexico in order to certify its importance in Mexican society and to measure its productivity.

Design/methodology/approach: The article presents an analysis of tobacco's productivity in Mexico in the 1980-2020 period, through the KLEMS methodology. Analysis of census samples from the period studied has confirmed the decrease experienced by this agricultural production.

Results: The importance of production has been visibly decreased within macroeconomic factors such as the Gross Domestic Product (GDP), which leads to a loss of participation of this agricultural product both in the national and international context. This has resulted in the contraction, in addition, ostensibly, of the number of jobs that are directly related to this agricultural activity and the ulterior consequences that come up for the family economy.

Limitations on study/implications: The statistical records from the period 1980 to 2020 were taken into account, since there were no records available before 1980.

Findings/conclusions: Through the research results, the decrease experienced by the tobacco industry from 1980 to 2020 was confirmed, and also that production will disappear at the industrial level.

Keywords: Total productivity of factors, tobacco, KLEMS.

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## Introduction

The tobacco industry in Mexico sets out social goals directed fundamentally at creating and preserving sources of employment in rural communities as a way to increase workers' income in this field, and of the families that depend on it. It has a quality that it shares internationally which identifies processes of concentration and monopolization of goods, and the tobacco industry has followed a pattern of business concentration and, consequently, of capital (Meneses, 2002).

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The state of Nayarit, as has been mentioned, occupies the first place in tobacco production, aspect that stands out since the first decades of the past century when it became a strategic place in the distribution of this production for Latin America (Mackinlay, 2008). An important aspect is the amount of workdays linked to this agricultural activity and the value of this production. In addition, tobacco production has developed under a contract agriculture scheme, which is not only still maintained but rather becomes a key piece both for the organization of production in peasant families devoted to this crop and for its living and working conditions (Pacheco, 2003).

According to the study by Madera and Hernandez (2016), the level of personal occupation in the industry continues to be very low compared to the last century, and actions have been implemented to improve this situation; results are slightly noticed, although they are still not as substantial so as to take them into account.

The tobacco industry, due to the adverse consequences generated by its consumption on health, has been levied with taxes that discourage its production and consumption in Mexico. It is taxed with a Special Tax on Production and Services (*IEPS*) and VAT, the first has an ad-valorem component of 160% and another specific one of $0.35 MX per cigarette. One of the objectives of the taxes is to reduce the consumption of tobacco in order to lower the incidence of diseases associated to smoking (Ibarra, Fuente and Miravete, 2021). Estimations were made which showed that an increase in the price of cigarettes of 10% could reduce the consumption in 2.5% ($p<0.05$) and increase tax collection in 16.11%; the result confirms the effectiveness of taxes as a tool for tobacco control in Mexico (Olivera *et al.*, 2010).

The tobacco industry is present in other states of the country, although the number of jobs linked to it is not significant in relation to the total; however, something that cannot be sidestepped is that employment in the rural sector linked to the agricultural activity of tobacco farming is important in terms of training, technical assistance, technological development, and the social benefits received by day laborers and their families (Waters *et al.*, 2010). The objective of this study is to analyze productivity of tobacco in Mexico during the 1980-2020 period, through the KLEMS methodology.

## MATERIALS AND METHODS

### KLEMS Model

Measuring productivity of the different factors that intervene in the production process has been included in the agenda of economic themes since Robert Solow (1957) and his "Technical change and the function of added production"; a natural and intuitive evolution of the function has been the KLEMS methodology which allows understanding the productive factors that contribute to the economic growth and production, as well as their performance in the productive process, which for decision makers is very important for the design of public policies in the country (INEGI, 2021).

Various authors have applied the method, for example Timmer, Mahony and Van Ark (2007). The accounts of growth and productivity of the European Union KLEMS include measurements of production growth, creation of employment and abilities, capital

formation, and multifactorial productivity (MFP) in the industrial level for the member states of the European Union since 1970. The entry measures include several categories of capital inputs (K), labor (L), energy (E), material (M) and services (S). O'Mahony and Timmer (2009) describe the contents and the construction of the KLEMS growth and productivity accounts; the database contains measurements of production, inputs and productivity at the industrial level for 25 European countries, Japan and USA, for the period of 1970 onward; the methodology used in the construction of the database and shows how it can be useful to compare productivity trends.

In Poland, the hypothesis was suggested that through the use of some innovative but acceptable evaluation techniques of missing data, it is possible to provide enough data for Poland for the accounts mentioned, after a general description of the KLEMS economic productivity accounts and the relevant fundamental methodology; the article presents more about how problems that have emerged of specific data have been solved (Kotlewski and Błażej, 2018). In addition, Goldar, Krishna and Aggarwal (2017) analyze the growth, structural change and advance in productivity of the Indian economy in the 1980-2014 period; the KLEMS approach takes into account the role that the inputs of capital, workforce, energy, materials and services have on the growth of production in the industries.

In Latin America, it was applied to analyze the economic growth, the productivity and its determinants in five countries, Argentina, Brazil, Chile, Colombia and Mexico, during the 1990-2010 period. The results showed that the slow economic growth is basically driven by the negative contribution of the total productivity of the factors (TPF) in all the countries and nearly all the sectors, despite the investment effort carried out in the last 20 years (Hofman, Mas, Aravena and Guevara, 2017). In Mexico, it was used according to Ibarra and Ros (2019) to estimate equations of the accumulation rate of the non-residential private capital in manufacture, tradable and non-tradable, in Mexico during the 1992-1994 period.

Banco de México (2015) found a positive correlation between growth of the TPF and that of production, as a result of this pattern, and causality tests were conducted for panel data in order to determine a possible causality between these two variables; it was found that the hypothesis of causality in both directions cannot be rejected at conventional significance levels. Another pattern resulting from INEGI data also show is that growth of the TPF, in addition to irregular, tends to concentrate in a few sectors. Since the structural changes in the Mexican economy in the decades of the 1980s and 1990s, a successful insertion into the global markets has been experienced, although the growth in productivity has been modest, which has led to low and volatile economic growth; despite a significant reassignment of hours worked between industries, their added impact has been obstructed by the prevalence of flows in the sectors with a high increase in labor productivity towards those with a lower or decreasing productivity growth, and the production factors are highly qualified both in workforce and capital have not shown a significant contribution to the increase in added value (Padilla and Villarreal, 2017).

**Linear correlation coefficient**

A positive Pearson's (1895) correlation between economic growth and flow of remittances, the correlation coefficient can be calculated through the following equation:

$$r = \frac{\sum xy}{\sqrt{\left(\sum x^2\right)\left(\sum y^2\right)}}$$

Where: $\sum xy$: is the covariance between *X* and *Y*; $\sum x$: is the typical deviation of *X*, and $\sum y$: of *Y*.

Pearson's linear correlation coefficient in the population will always be unknown and it will be estimated through the one obtained in the sample. An equivalent expression (Martínez *et al*., 2014) is:

$$r = \sum (xi - \bar{x}) \cdot \left(yi\ n\ i = 1 - \bar{y}\right) \sum (xi - \bar{x}) 2 \cdot \sum \left(yi - \bar{y}\right) n2\ i = 1\ n\ i = 1$$

The other method is by Luquez, Gómez and Hernández (2021), with the aim of characterizing the production and generating a general outlook of the situation of different competitors. The growth rates of the indicators chosen were calculated for the analysis of exports with the following formula:

$$Tc = \left(Vf - Vi \,/\, Vi\right) * 100$$

Where: *Tc*: is the growth rate; *Vf*: at final value; *Vi*: refers to the initial value.

The research process was affected importantly by the global COVID-19 pandemic, which limited the physical consultation of documents, economic atlas, industrial census, economic census in libraries, and other institutions that protect these materials. All of the data were obtained virtually (INEGI, 2022), which impacted the selection of the time period to be studied, that is, from 1980 to 2020, and the databases were elaborated to then load and process them in the STATA12.0 software.

**RESULTS**

Data analysis was carried out, finding the correlations represented in Table 1. The gross production is positively related with the number of businesses; they have a correlation of 40.82%, which means that as the number of businesses devoted to the harvest, production and commercialization of tobacco increases or grows the gross production available to be offered also increases. At the same time that the relationship between the number of businesses and the gross production is positive, the latter maintains a stronger although positive relationship with the number of jobs used in all the levels necessary to make tobacco reach households or businesses of consumers; the correlation found in the period analyzed between these two variables is 71.55%, and in

**Table 1**. Correlations by tobacco variables.

| | Gross production | Number of companies | Number of employees | Gross value added | Total energy costs | Ttotal expenditure on raw materials | Total fixed assets | Total expenses in services | Total advertising expenses |
|---|---|---|---|---|---|---|---|---|---|
| Gross production | 1 | | | | | | | | |
| Number of companies | 0.7155 | 1 | | | | | | | |
| Number of employees | 0.4082 | −0.0526 | 1 | | | | | | |
| Gross value added | 0.4919 | 0.6924 | −0.459 | 1 | | | | | |
| Total energy costs | −0.6128 | −0.9388 | −0.1188 | −0.5203 | 1 | | | | |
| Total expenditure on raw materials | 0.5093 | 0.5208 | −0.2125 | 0.921 | −0.3987 | 1 | | | |
| Total fixed assets | 0.9468 | 0.6707 | 0.4835 | 0.2557 | −0.594 | 0.2156 | 1 | | |
| Total expenses in services | −0.4714 | −0.8617 | 0.0211 | −0.4935 | 0.849 | −0.3121 | −0.4634 | 1 | |
| Total advertising expenses | −0.4352 | −0.7826 | −0.1297 | 0.3283 | 0.7826 | −0.2054 | −0.4469 | 0.8864 | 1 |

Source: Prepared by the authors.

terms of the gross production and the added value, they have a correlation of 49.19% between both variables.

Gross production has a solid correlation that amounts to 94.68% with the total fixed assets, and 50.93% of positive correlation with the variable total expenditure in raw materials, showing that when there is a higher amount of fixed assets, it is the originator to produce a higher amount of product without leaving aside all the expenses in necessary inputs to comply with these high production quotas. The existing relationship between gross production and the expenditures in energy is negative. The correlation between these two variables is 61.28%, which implies that when a greater amount of energy can be consumed to produce, it is used with negative productivity, attaining a growth rate under zero.

The relationship there is between the variable gross production and the variables expenses in services and expenses in advertising is negative in the gross production with both variables, although it was certainly not as strong as the case of other variables; regarding the expenses destined to services, there is a correlation of 74.14%, while for the expenses focused on promotion, advertising and sponsorships, the correlation reaches 43.52%, showing that as the production grows, it is necessary to invest increasingly less in advertising to reach markets, even those unknown, than what is required as the part referring to services within the intermediate consumption.

The number of employees variable maintains a negative relationship with four variables among the nine studied; the variables number of businesses, total expenditure on energy,

total expenses in services, and total expenses in advertising, has a correlation of 93.88% with the total expenditure in energy while the correlation is 86.17% with total expenses in services, and in addition to these ratios, the number of employees in the industry has a correlation of 78.26% with total expenses in advertising and 5.26% with the number of businesses in the sector. This entire situation shows a lack of social policies in order to promote jobs, particularly for rural communities, although at the same time, the presence of new machinery that consume a higher amount of energy and a lower number of workers is undeniable.

Positive ratios were obtained of the employees with the rest of the variables studied: gross added value, total expenses in raw materials, and total fixed assets; the correlations with these variables mentioned are 69.24%, 52.08% and 67.07%, respectively, manifesting with the figures that as the number of employees increase, the total expenses in raw materials also increase. This takes into account that not all of it us used in the productive process as such, but that the consumption of materials also increased because since there are more workers in the industry there must be more mistakes at the time of consumption, among other elements that somehow spend inputs only for the employees; the total fixed assets also increase, since the higher number of workers bring with them the need to obtain a greater amount of productive tools and elements. Table 1 shows the correlation matrix.

Some other variables that were analyzed were the number of businesses, fixed assets and total expenses in services; the correlation is positive with each of them, of 48.35% and 2.11%, respectively. This denotes that as the number of businesses increase in the Mexican tobacco industry, an increase is also manifested in the amount of assets available for production. The relationship between businesses and employees behaves negatively and is almost inversely proportional; something similar happens between the number of businesses and the gross added value, and the total expenditure in energy, the variables total expenses in raw materials, and total expenses in advertising, promotion and sponsorship. The relationship with these four variables is negative, although it is certainly not as strong as the existing correlation between the total expenses in raw materials and total expenditure in energy, showing a correlation of 21.25% and 11.88%; the correlation between number of businesses and gross added value reaches 45.95%, demonstrating that as the number of businesses in the sector increases, an increase in the value added to the production is not seen, as it was expected to happen.

The gross added value has a negative relationship with most of the variables related; regarding the total expenditure in energy, a negative correlation of 52.03% was obtained, which is explained by the fact that as the value added to the final product increases, a lower amount of energy destined to achieving this productive and commercial purpose is necessary in most cases. With the total expenses in services variable, it maintains a correlation of 49.35%, it is directly related to the expense in intermediate consumption necessary to increase the value added to the production, when investing less time and intermediate goods of service in attaining an increase in the added value to the product, the investment in advertising, marketing and promotion destined to this aim would also have a negative relationship.

The gross added value is positively related with the amount of total fixed assets, the correlation is 25.57% which evidences the need to acquire more fixed assets to the extent that the purpose is to increase the value that should be added to the production; the ratio with the total expenses is higher, with 92.10%, and as the gross added value to the product increases, the total expenses in raw materials increase almost to the same measure. The total expenditure in energy manifests negative relationships with the consumption of energy, and in total expenses in raw materials and total fixed assets, the correlation is 39.87% and 59.40%, respectively, expressing negative parameters since there is no need to have a higher amount of machinery and equipment because there is less machinery but which consume less amount of inputs even when they consume more energy of every type.

The existing correlation between the consumption of materials and inputs with total fixed assets is 21.56%; this ratio is positive and reflects the need for consumption in resources to produce increasingly more as the amount of machinery destined to production increases; the correlations with total expenses in services and total expenses in advertising are negative, of 31.21% and 20.54%, respectively, implying that as the total expenses in raw materials increase, the expenses in services and advertising also increase, although in an inversely proportional manner. The total fixed assets have a negative ratio with the variables expenses in services and total expenses in advertising, where the correlation is 46.34% and 44.69%, respectively, implying less expenses in both variables while the amount of fixed assets increases, and this is reflected in lower levels of production and therefore lower expenses in intermediate consumption destined to services to produce what is required by the demand. Figure 1 illustrates that throughout the last 30 years large amounts have been sustained destined to advertising, promotion and sponsorship, variation rates are present mostly increasing, ranging from 2% until reaching a level of 45%, going through intermediate levels but at the same time showing some value that denotes a decreasing variation that ended in the first decade of 2000; a growing trend is seen in the progress which refers to the amounts spent in fulfilling the sales goals both at the national and the international level.

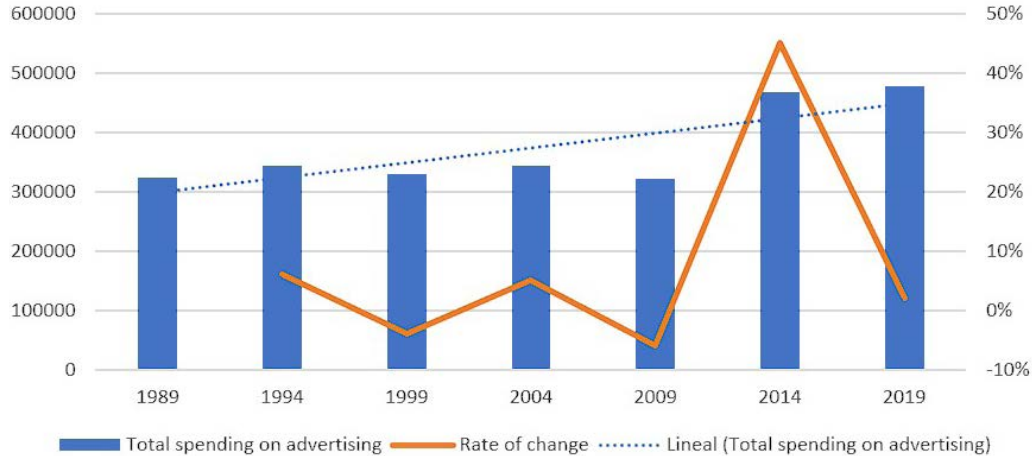


**Figure 1**. Total expenses in advertising, their variation rates and tobacco trends. Source: Prepared by the authors with data from INEGI.

Regarding the intermediate consumption, mostly increasing variation rates are seen which range from 1% to a level of 15% going through intermediate levels, but at the same time a value is seen that denotes a marginally decreasing variation that ends in the first decade of 2000. Figure 2 shows the peaks, both increasing and decreasing, in the percentage evolution of total expenses destined in services to produce.

Equipment and machinery are acquired with the aim of increasing production and utilities. Next, the variation rates are presented graphically, which were mostly increasing and range from 1% to a level of 206% passing through intermediate levels, and there were also negative variations. Figure 3 shows how the total expenses destined to having a higher amount of fixed industrial assets have increased, with the aim of reaching the productive goals planned in sectorial strategies.

Figure 4 shows the behavior of the acquisition of raw materials and inputs, which show mostly constant variation rates that range from 0% to a level of 3%, passing through

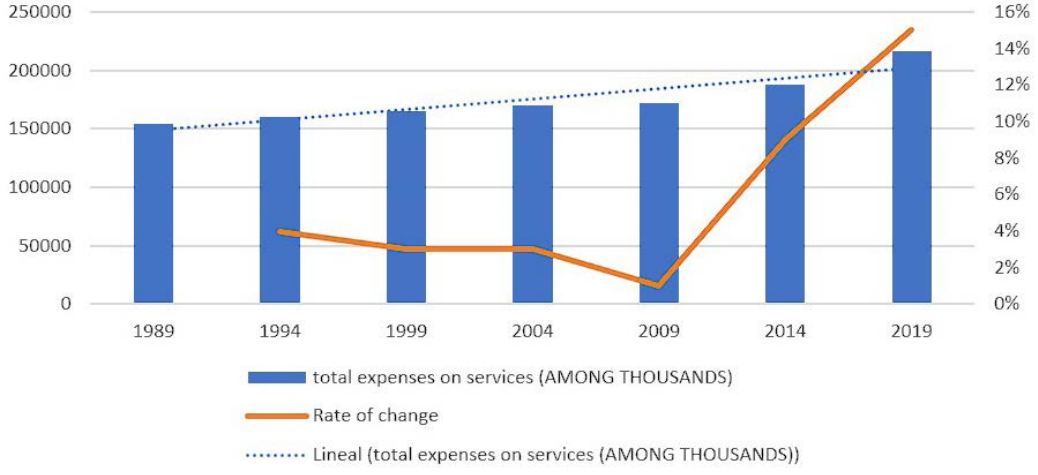


**Figure 2**. Total expenses in services, their variation rates and tobacco trends. Source: Prepared by the authors with data from INEGI.

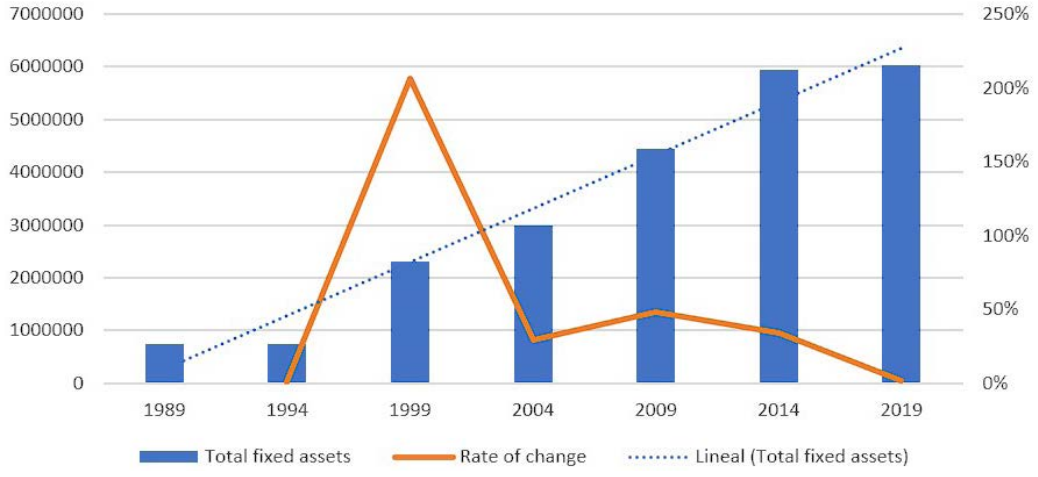


**Figure 3**. Total fixed assets, their variation rates and tobacco trends. Source: Prepared by the authors with data from INEGI.

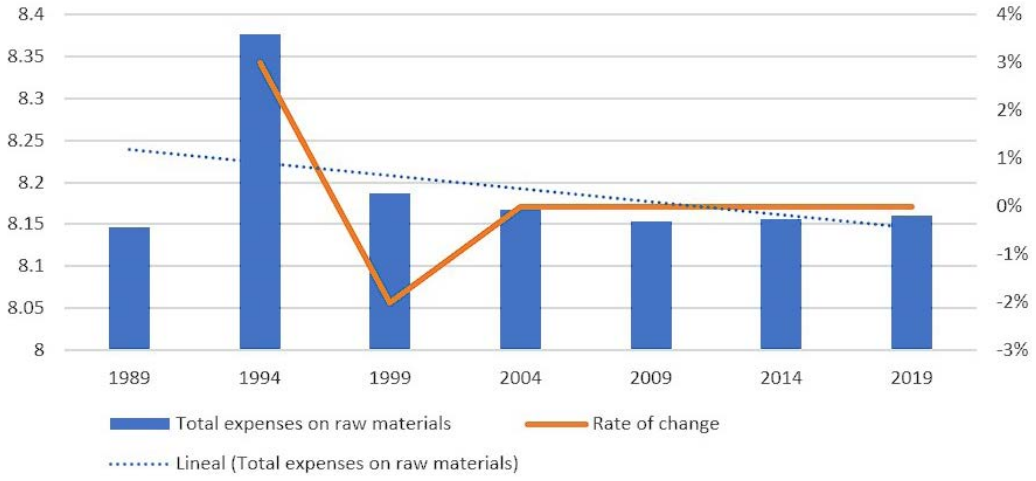


**Figure 4**. Total expenses in raw materials, their variation rates and tobacco trends. Source: Prepared by the authors with data from INEGI.

intermediate levels that are rather discouraging; the continuous line shows both increasing and decreasing peaks in the percentage evolution of expenses in raw materials, and a decreasing trend is seen which has implied a decrease in general of production in the sector; the general trend is decreasing.

The energy consumption has increased with the aim of increasing production and utilities. Figure 5 presents the variation rates that are mostly increasing, which range from 2% to a level of 68%; at the end of the second decade of 2000, some negative values are seen, and this is shown by a discontinuous line in general with an increasing trend with a very accentuated slope; both the increasing and decreasing peaks are shown.

It was identified that there are increasingly less investments to add the best level possible to the final product; mostly decreasing variation rates are seen, which range from 140% to a level of 199% passing through intermediate levels, although at the same time, there are some values that denote a decreasing variation from the beginning of the

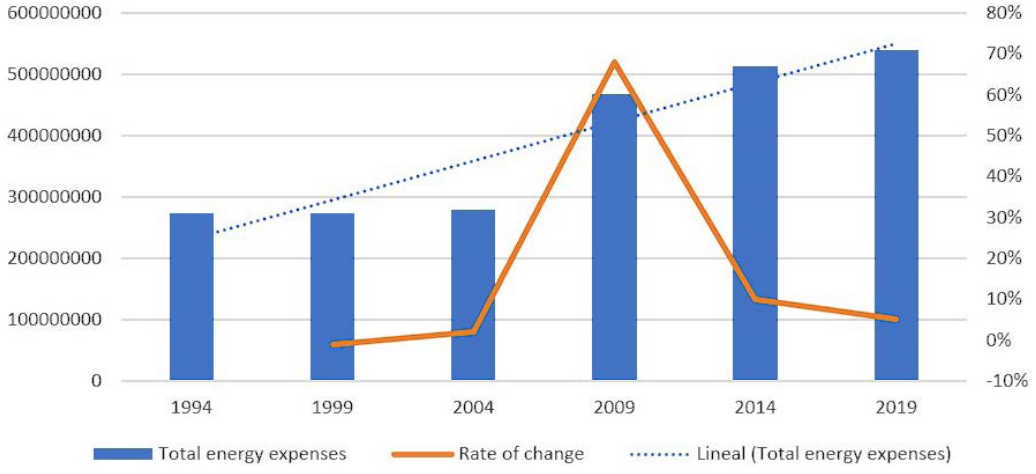


**Figure 5**. Total expenditure in energy, their variation rates and tobacco trends. Source: Prepared by the authors with data from INEGI.

second decade of 2000. In the four decades analyzed, a very strong decreasing trend is seen in the evolution referring to the amounts spent in adding value to the production, as can be seen in Figure 6.

Throughout the four decades analyzed, a very strong descending trend is seen in the evolution referring to the amounts generated by the total gross production, as can be seen in Figure 7. In these years lower and lower investments are seen, destined to producing a higher amount of the final good, to increase the utilities in the Mexican tobacco sphere. In this sector, mostly decreasing variation rates are seen which range from 109% to a level of 199% passing through intermediate levels, although at the same time, there are some values that denote a decreasing variation from the beginning of the second decade of 2000.

In this sector, mostly decreasing variation rates are seen, which range from 3% until reaching totally negative levels; they reach 23% and pass through intermediate levels,

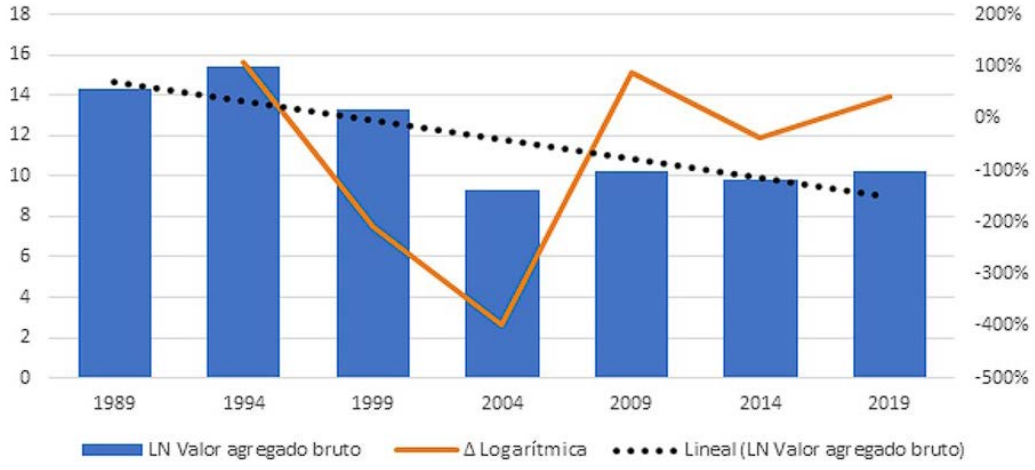


**Figure 6**. Gross added value LN, variation rate and trend line of the gross added value. Source: Prepared by the authors with data from INEGI.

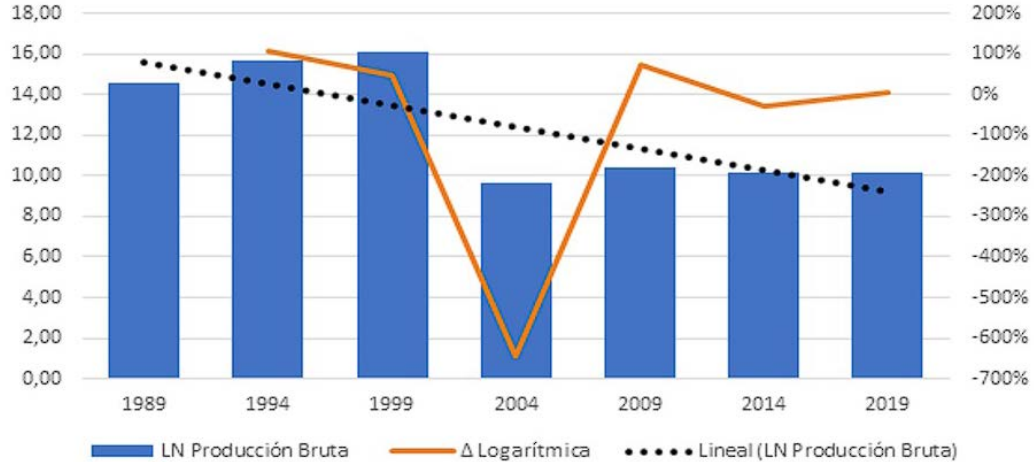


**Figure 7**. Gross production LN, variation rate and trend line. Source: Prepared by the authors.

rather discouraging, values that denote decreasing variations throughout the entire period studied. Throughout the four decades analyzed, a rather decreasing trend is observed in the evolution referring to the numbers of employees used for production, as seen in Figure 8.

As Figure 9 shows, quite decreasing levels have been maintained in the number of businesses. In this sector there are variation rates that are mostly decreasing, which range from 23% to a level of 95% passing through intermediate levels, although at the same time, there are some values that denote really worrying decreasing variations since the year 2000 began. Throughout the four decades analyzed, a very stable trend is observed, although increasing in the evolution referring to the number of businesses operating in this sector, as can be seen in Figure 9.

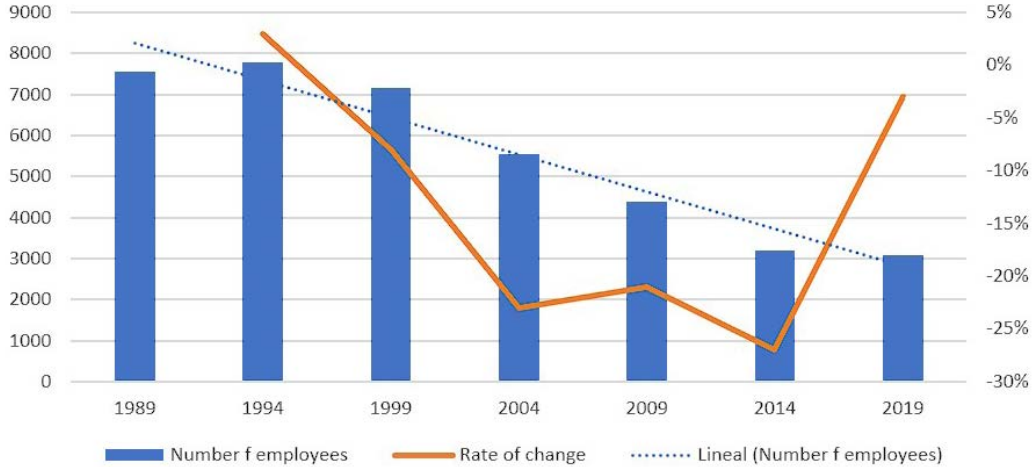


**Figure 8**. Number of employees, their variation rates and tobacco trends. Source: Prepared by the authors.

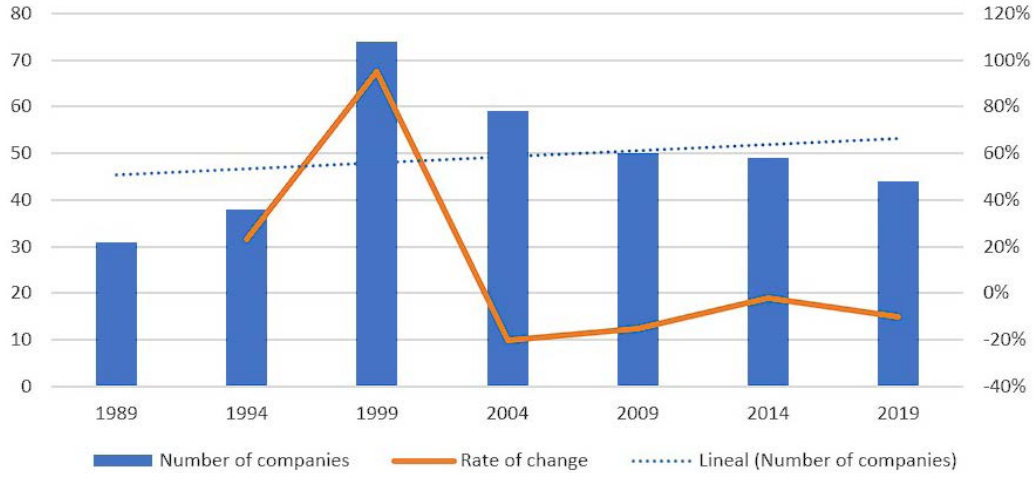


**Figure 9**. Number of businesses, their variation rates and tobacco trends. Source: Prepared by the authors.

## CONCLUSIONS

Throughout the last four decades, the Mexican tobacco industry has contracted, especially the number of employees, and in this sector negative variations have been seen since the middle of the 1990s and until today. The conclusion is that the level of productivity in the tobacco sector has been kept in constants, with both positive and negative peaks with a strong attraction to decrease, particularly in the last 25 years, regardless of the amount of investment applied in the industry. Practically half of the variables and indicators have an inversely proportional relation to the capital destined to this national product.

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