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Tax strategies for reducing CO2 emissions in the automotive industry in Mexico

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Abstract

The manufacturing industry, especially the automotive industry, plays a key role in Mexico, but also has a significant impact on the environment due to its high carbon dioxide emissions. We analyze how the automotive industry contributes to the country's economic growth while facing critical environmental challenges. The methodology used includes an econometric model that evaluates the negative externalities of automotive production and proposes a framework for calculating taxes to incentivize more sustainable practices. The results indicate that, despite the importance of the automotive industry, only 0.09% of vehicles sold in 2021 were electric, highlighting the urgent need for effective public policies. The Glasgow Pact sets ambitious targets to reduce carbon emissions, with a commitment that at least 50% of vehicles sold in Mexico will be zero-emission by 2030. However, achieving this goal requires significant investment in infrastructure and a change in fiscal policies. A Pigouvian tax on CO2 emissions generated by the automotive industry is proposed to internalize these externalities and encourage the adoption of clean technologies. Through econometric analysis, we seek to determine the optimal tax to mitigate the negative impact of automotive production on other companies and the environment. It highlights the need to implement effective policies that align economic interests with international environmental commitments, thus guaranteeing sustainable development in Mexico.

Keywords

Automotive industry, carbon dioxide emissions, government policy.

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Introduction

Manufacturing plays a fundamental role in the current lifestyle of societies, as it represents a considerable proportion of consumer goods and daily utilities. Nonetheless, this industry has been active for much of human history, and as it has improved its processes in pursuit of higher production, it has also led to the use of more resources and environmentally friendly methods, without considering sustainability.

The automotive industry is significant to Mexico, given that it has several states in which transnational companies have established their production plants. This has contributed to the increase in the employed population and the country's Gross Domestic Product. However, currently, the manufacture of these vehicles continues to be carried out under the lowest standards in terms of caring for carbon dioxide emissions, with only 0.09% of cars sold being electric, according to reports from the first months of 2021 (Mendoza, 2022).

The Glasgow Pact, established during the COP26 summit, brings together more than thirty countries, major car manufacturers and regions committed to phasing out petrol and diesel vehicles, to make zero-emission vehicles the norm by 2035 in key markets and 2040 in the rest of the world. This pact seeks to ensure that these vehicles are accessible, affordable and sustainable by 2030.

In this context, Mexico is committed to being part of this transition to sustainable mobility. During COP26, the country joined 30 other countries in the effort to make zero-emission vehicles a common reality. Mexico has announced an increase in its commitment to reduce emissions from 22% to 35% by 2030, which includes specific actions such as closing coal plants and promoting low-carbon transportation.

To meet these goals, it is estimated that at least 50% of vehicles sold in the country must be zero-emission by 2030, which would require selling around 600,000 electric vehicles annually. However, this goal faces significant challenges due to the need for effective public policies that foster the investment and infrastructure needed to support this transition.

In line with the Sustainable Development Goals, the goals with which this work is aligned are:

Goal 9 Industry, innovation and infrastructure: Promote inclusive and sustainable industrialization. Goal 12 Responsible consumption and production: Encourage enterprises, especially large corporations and transnational corporations, to adopt sustainable practices and incorporate sustainability information into their reporting cycle.

The article follows a methodical and coherent structure that allows for a comprehensive approach to the problem of pollution in the automotive industry in Mexico.

It begins with an introduction that sets out the global and national context on urban growth and its consequences, such as air pollution. Below is a literature review detailing the sources of pollution, the policies needed to regulate emissions, and the crucial role of the automotive industry in this scenario. The methodology focuses on an econometric model that assesses the negative externalities of automotive production and proposes a framework for calculating taxes that incentivize more sustainable practices.

In the analysis and results section, findings on current car production and recommendations for public policies that promote the transition to electric vehicles are presented. Finally, the article concludes with a synthesis that highlights the need to implement effective policies to meet international environmental commitments, ensuring that companies contribute positively to the environment without unfairly burdening those who suffer the consequences of pollution.

Literature review

It is projected that by 2050, 70% of the global population will reside in urban areas. In Mexico, since 2010, 77.8% of the inhabitants already live in urban locations; in addition, this has given rise to various interrelated problems, such as: traffic congestion, air pollution, energy security, effects of climate change, overpopulation, increase in the demand for basic services and centralization, among other aspects according to the Business Coordinating Council (Sandoval Garcia, 2019)

As Sandoval Garcia (2019) mentions, concerning environmental pollution in the Metropolitan Area of the Valley of Mexico, cars are one of the main sources of pollution; that is, their daily use contributes significantly to this problem. Daily, these vehicles consume 4.5 million litres of diesel, 18 million litres of gasoline and 700,000 litres of liquefied petroleum gas. Some 52% of cars that use gasoline are models before 1990, which are responsible for 68% of pollutant emissions due to gasoline combustion, mainly because they lack the appropriate technology to mitigate emissions, such as catalytic converters.

The automotive industry sector, composed of both the terminal industry and the auto parts industry, undoubtedly has a relevant role within the current national economy. (Vicencio, 2007)

From the point of view of Ruiz (2023), for industrial sectors that directly or indirectly generate Greenhouse Gases (GHG), there must be a stricter regulatory policy with short, medium and long-term commitments, which involves incentives and fiscal sanctions so that entrepreneurs in these sectors are forced to make the required technological changes within a reasonable period. An important branch, in this case, is the automotive industry, which does not directly generate a high level of emissions, but the transport it manufactures does, which produces a large emission of GEl in other sectors and consumers so that it requires greater regulation and stimuli so that it no longer modifies its technology but the product

itself that is manufactured.

It is a great change that cannot happen overnight, but there needs to be a program oriented in that direction. In general, the State must use the industrial policy instruments at hand with a sustainable development orientation. There are three policy instruments: monetary policy on credit, trade policy on imports and exports, and fiscal policy, both in public expenditure (subsidies) and in revenue (taxes). The key to the success of these policies is coordination between the three.

Factors such as skilled labour, low wages and low production costs are the reason why automotive companies have chosen to bring part of their production chains to Mexican territory; therefore, FDI destined for this industry represents more than a third of total investments. (García-Remigio, 2020).

The USMCA (Agreement between Mexico, the United States and Canada) is fundamental for the Mexican automotive industry, mentions The Logistics World, as it establishes stricter rules of origin than its predecessor, NAFTA. This agreement has facilitated access to international markets, eliminating tariff barriers and allowing Mexico to increase its participation as one of the main exporters of vehicles. In addition, it has created a favourable environment for foreign direct investment, promoting the modernization of facilities and the development of new plants, which generates employment and contributes to the country's economic growth.

In turn, the USMCA imposes significant environmental responsibilities by establishing stronger labour and environmental standards. One of its goals is to encourage more sustainable practices in the automotive industry, which means that companies must adopt clean technologies and reduce their carbon footprint. While this represents a challenge due to the investments required, it also offers opportunities to lead in environmental innovation. Mexico's ability to adapt to these changes will not only determine its competitiveness in the global market but will also reflect its commitment to sustainability and the reduction of CO2 emissions in the automotive sector.

Bruckmann says that another key area is the transport sector, which accounts for 25% of greenhouse gas emissions in Europe. The goal of a 90% reduction in carbon emissions in this sector by 2050 necessarily implies a systematic and increasing replacement of conventional vehicles; however, this presents significant challenges, which use different fossil energy sources, for hybrid electric vehicles (HEVs) and electric vehicles (EVs). One of the objectives set establishes that by 2025 at least 13 million EVs will circulate in the EU and one million public charging stations will be available.

Determine the percentage of taxes or incentives to the automotive manufacturing industry that should be established by government policies to comply with the characteristics agreed in the Glasgow Climate Pact (soft law), to achieve the goal that by 2040 all vehicles sold in

the world comply with these specifications, as established at the ministerial meeting for the Transition to Zero Emission Vehicles at the United Nations Conference on Climate Change (COP26).

Given the current situation of production in the post-pandemic automotive industry, this study will analyze the total production of automobiles, not limited to electric vehicles alone. This is because the automotive industry in Mexico has not yet recovered production levels before the SARS-CoV-2 pandemic; therefore, it is crucial to implement incentives. Therefore, the total number of cars produced will be considered, with the expectation of implementing incentives that facilitate the transition from internal combustion vehicles to electric, while increasing total production. In other words, an increase in overall production is anticipated, gradually transforming supply towards electric vehicles.

To achieve this objective, the following activities were developed:

1. To analyze the current levels of automobile production in Mexico.
2. Assess the need for government taxes or incentives to meet the target set out in the Glasgow Climate Pact.
3. Propose public policy recommendations to encourage the production of cars that comply with the characteristics of the Glasgow Climate Pact.

To find a viable solution so that Mexico can comply with the commitments made in the Glasgow Climate Pact, through the establishment of effective government policies that encourage the production of greener and more sustainable vehicles.

Methodology

It is proposed to apply an externality model, where an externality is defined as what happens whenever the activities of one economic agent affect the activities of another in a way that is not reflected in market transactions (Nicholson and Synder, 2008).

In principle, you have a company x that produces a quantity of products X according to the following expression:

$$X = Al_x^{\beta} \qquad (1)$$

Where the factor A represents the level of technology with which it operates, and the level of workers l_x used to produce X units by the company x. The level of technology drives economic progress by increasing the productivity of the factors of production (Barro and Sala-i-Martin, 2009) and in some cases, the value of A is set to 1 to simplify the models, implying that any technological improvement directly translates into a proportional increase in total output. On the other hand, βrepresents the sensitivity or impact that an increase in the level of workers has on the production of the good X.

The production of the good X has a significant impact on the production of the good Y, according to:

$$Y = \begin{cases} Bl_Y^{\alpha}(X - X_0)^{\alpha} & si\ X > X_0 \\ Bl_Y^{\alpha} & si\ X \leq X_0 \end{cases} \quad (2)$$

Where X_0 represents a threshold to produce X, which if exceeded causes a negative externality; l_Y represents the number of workers needed to manufacture said good and the value of α represents the externality caused by production of X on production of Y. If $\alpha = 0$ then the x company's output does not affect the output of the good Y, but if $\alpha < 0$, an increase in x output above the threshold x_0 will cause such an externality in the output of Y.

In this way, and intending to reduce the level of impact of the x company externality, the government applies a tax t, called Pigouvian (Synder and Nicholson, 2008), which under equilibrium conditions complies with:

$$(p - tp)\frac{\partial X}{\partial l_X} = w \quad (3)$$

Expression (3) intuitively shows that the marginal productivity of a new worker, after deducting tax, is equal to the wage paid to that worker. In this case, p is the price of the product X in the goods market, and w is the equilibrium wage in the labour market.

The externalities methodology proposed by Professor Nicholson in his book is relevant to analyzing and designing fiscal strategies aimed at the automotive industry in Mexico. This methodology allows us to understand how economic activities can generate collateral effects not reflected in market prices, which is particularly relevant in the context of the automotive industry, which has a significant impact on the environment and the economy.

Externalities are costs or benefits that affect third parties and are not reflected in market prices. In the case of the automotive industry, emissions of CO2 and other pollutants are negative externalities that result from the production and use of vehicles. Nicholson's methodology allows quantifying these externalities and suggests that to achieve an efficient allocation of resources, it is necessary to internalize them through taxes or fiscal incentives. Using the externalities methodology, a tax system can be proposed that imposes taxes on CO2 emissions generated by the automotive industry. This would incentivize companies to adopt cleaner technologies and reduce their environmental footprint. By setting a price for emissions, it seeks to align private interests with social welfare, thus promoting more sustainable production.

Econometric Methodology

The main objective of the article is to determine the optimal tax on the automotive industry to mitigate the reduction of the negative externality caused to other companies. To do this, we will estimate expression (1) and then apply expression (3). And to estimate expression (1), in addition to the information, basic concepts of econometrics are needed.

In this way, an econometric analysis relates the importance of the independent variables to the dependent variable. Such a relationship must meet two conditions: i) the intuitive part that reflects the expected theoretical analysis and, ii) the statistical significance that shows the minimum explanation error committed by the independent variables over the dependent one. To capture conditions (i) and (ii), we rely on the following linear expression,

$$Y_i = a_0 + a_1 X_{1i} + a_2 X_{2i} + \cdots + a_k X_{ki} + U_i \qquad (4)$$

where Y_i represents the dependent or explained variable and $X_1, X_2, \ldots, X_k$ the k possible independent variables. The coefficients a_j represent the effects of the changes of the independent variables on the dependent variable, expressed as $\frac{\partial Y_i}{\partial X_{ji}} = a_j$, for $j = 1, 2, \ldots, k$. On the other hand, U_i represents uncontrollable and random variables, called disturbances, classic examples of these disturbances are a crisis, a war, and a pandemic, among others. Expression (4), which considers the effects of the independent variables on the dependent variable, together with the disturbance factor, represents an econometric model.

To find the values of the coefficients a_j $(j = 1, 2, \ldots, k)$, ordinary least squares (OLS) are used, which estimate the average behaviour of Y_i given the observations $X_1, X_2, \ldots, X_k$, that is

$$\widehat{Y_i} = E(Y_i | X_1, X_2, \ldots, X_k,) = \widehat{a_0} + \widehat{a_1} X_{1i} + \widehat{a_2} X_{2i} + \cdots + \widehat{a_k} X_{ki}$$

To verify if the variables $X_1, X_2, \ldots, X_k$ are individually significant over Y_i, the following hypothesis test (PH) is proposed

$H_0: a_j = 0$ vs $H_a: a_j \neq 0$, para (5)$j = 1,2, \ldots, k$

Finally, to verify the veracity or not of the PH, the values of p (probability of error) are used. A $p_{value} < 0.05$ shows that the variable X is statistically significant in explaining behaviour of Y_i, at least 95% confidence.

Analysis and results

Based on information from the National Institute of Statistics and Geography (2024), the following data are available:

X: Automobile Production

l_X: Employed personnel in the automobile manufacturing industry

tp: Percentage of the price that will be the government tax or incentive

w: Average salary paid to the worker in the automotive industry.

To estimate expression (1), we first linearize it,

$$lnX_t = lnA + \beta lnl_X + U_t \qquad (6)$$

$$lnY_t = lnB + alnl_Y + U_t \qquad (7)$$

Since the objective of this study is to focus specifically on the industry that affects other economic agents, it is chosen to use only the equation corresponding to the company X, which allows a more direct and accurate assessment of the externalities in question. Thus, from the information obtained and generated, the estimate of (6) is,

$$\widehat{lnX_t} = 0.7375\ lnl_X \qquad (8)$$
$$p_{value} \quad (0.0000)$$

Notice in estimation (8) that we do not consider the constant A, which we could without loss of generality equal to 1. From (8) we can retrieve the estimate of the original expression (1), which is as,

$$\hat{X} = l_X^{0.7375} \qquad (9)$$

From the expression (9) we can know the number of workers required to meet a permitted level of production, called the threshold X_0. In our analysis, we assign the maximum number of automobile production in the automotive industry in Mexico, which is 91,716 (INEGI, 2024). In this way,

$$\hat{X} = l_X^{0.7375} = X_0 = 91716 \qquad (10)$$

This sets an optimal level of 5,354,749 workers. This number of workers must comply with expression (3): $(p - tp)\frac{\partial X}{\partial l_X} = w$,

The values for the equilibrium relationship to be fulfilled were deduced as follows:

w: Wages were constructed with the average hourly price of a worker in the auto industry, which is $58.50. Considering an average of 7.5 hours worked per day, a total of 438.75 pesos per day is obtained, which is 1.78 times more than the general minimum wage established for 2024. Considering that the average number of days worked per month in Mexico is 21 days, an average industry salary of 9,213.75 pesos per month is obtained, which annually translates to 110,565.00 Mexican pesos. That is, w =110565, pesos.

As a second step, we got $\frac{\partial X}{\partial l_X} = 0.7375 l_X^{-0.2625}$ and the optimal number of workers that met the threshold $X_0 = 91716$ was replaced, and we got $l_X = 5354749$ as a result.

Finally, for this expression, an average car price of 400,000 Mexican pesos is considered, this is $p = 400000$

To visualize this result, a table was made (Table 1) in which the calculations and the progress sought by the country in the production of electric cars are added.

Table 1. Production of automobiles with applicable tax or subsidy

YEARS REMAINING*	YEAR	PERCENTAGE OF ELECTRIC CARS PRODUCED	ELECTRIC CARS PRODUCED	TAX OR SUBSIDY
1	2025	6.25%	5,732	-7.16%
4	2028	25%	22,929	-12.36%
8	2032	50%	45,858	-16.10%
12	2036	75%	68,787	-18.75%
16	2040	100%	91,716	-20.88%

YEARS REMAINING FROM 2024 TO MEET THE GLASGOW CLIMATE PACT TARGET

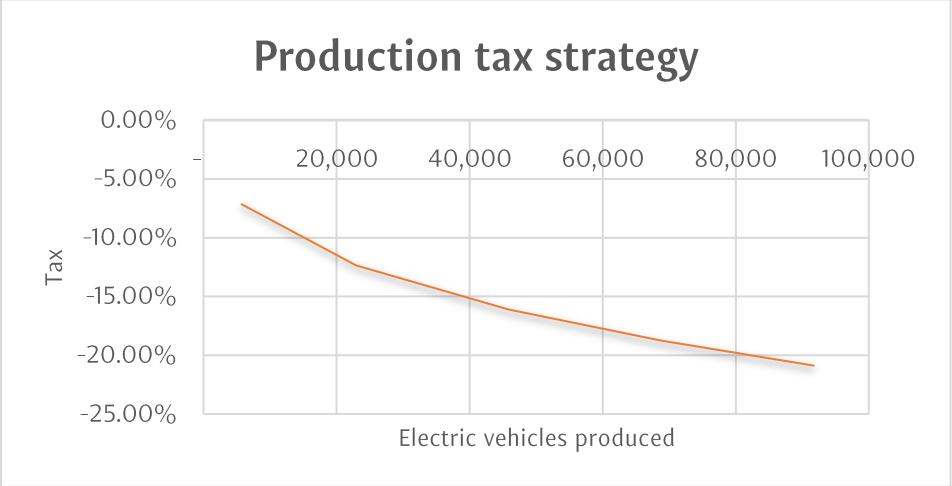
Column 1 of Table 1 shows the progress in years to meet the goal signed by Mexico in the Glasgow Climate Pact. Column 2 represents the percentage of agreement with the number of years still to meet the target in 4-year terms. Column 3 shows the number of cars to be produced, considering as maximum possible production the maximum value recorded in the years considered in the database. Column 3 shows the tax or subsidy that the government must apply to reach that threshold.

Table 2. Average profit per production and fiscal strategy in monetary terms

AVERAGE INDUSTRY PROFITS FOR ELECTRIC VEHICLES	TAX STRATEGY	FISCAL STRATEGY IN MONETARY TERMS
$ 2,292,900,000.00	-7.16%	$ (164,091,713.98)
$ 9,171,600,000.00	-12.36%	$ (1,133,583,457.63)
$ 18,343,200,000.00	-16.10%	$ (2,952,874,561.02)
$ 27,514,800,000.00	-18.75%	$ (5,159,686,398.06)
$ 36,686,400,000.00	-20.88%	$ (7,660,903,239.64)

Table 2 presents the average amount of profit that would be obtained from the manufacture of electric cars, as well as the fiscal strategy necessary in monetary terms to materialize the production target. This allows the fiscal share to be quantified clearly and understandably. In addition, Graph 1 is included, which provides a visual representation of this data, thus facilitating its interpretation and analysis.

Figure 1. Relationship between the tax strategy according to the number of cars produced



These results demonstrate how government policies can support Mexico to meet the established objective so that effective support is provided to the manufacturing industry in its automotive sector.

Discussion

Our work shows a trade-off between maintaining healthy employment and containing some production in the automotive industry. This is due to the fact of mitigating externalities derived from pollution and excess in the automotive industry. This relationship between employment and taxes, as can be observed in Andrade (2024), the author shows that excessive tobacco production implies a negative externality in consumers that sometimes translates into death. However, stopping their production implies a cut in personnel, which would also generate "shame" and disgust in society. Part of Andrade's results is that there is more damage from staff cuts than excess production, which derives from the analysis that it is better to subsidize production than to mitigate it through a tax.

On the other hand, according to Ruíz (2023), for industrial sectors that generate Greenhouse Gases (GHG), it is essential to implement stricter regulatory policies that include fiscal stimuli, which can force entrepreneurs to make necessary technological changes within a reasonable period. This highlights the need to balance production and employment, considering that the transition to a more sustainable industry should not compromise workplace well-being.

It is known that the internal combustion engine that uses gasoline was the one that consolidated the dominance of oil and that this commodity has a strong importance in the market as well as the interests of those with power. Although early automakers experimented with steam and electric engines, it was with Henry Ford's introduction of the Model A in 1903 that the gasoline engine demonstrated its superiority in power and range.

With the introduction of automobiles, oil established a true monopoly in the sector (Amórtegui, 2022).

Similarly, innovation has been widely recognized as a key source of competitive advantage for both companies and countries, especially in those that are leading industrialization and in those that are beginning to seek competitiveness in a globalized environment. This phenomenon is because the ability to innovate allows organizations to adapt and thrive in an ever-changing market, where differentiation becomes essential for success. Companies that implement innovation strategies, whether incremental or disruptive, can improve their processes, products, and services, which gives them a privileged position compared to their competitors (Unger, 2011)

In addition, according to Bruckmann (2022), ambitious targets to reduce carbon emissions in the transport sector require a systematic replacement of conventional vehicles with electric ones. This change depends not only on the will of the market but also on adequate tax incentives that facilitate this transition. Thus, it is evident that the implementation of effective fiscal policies can be crucial to achieving a balance between sustainable production and job creation in the automotive industry.

It is important to consider that the cost of acquiring an electric vehicle is significantly higher compared to that of internal combustion, which is why Sanz Arnaiz (2015) mentions that it has led many consumers not to opt for it when buying. However, this is not the only aspect that influences the purchase decision. Most potential buyers do not have information about the advantages offered by electric vehicles.

One way to facilitate their entry into the market is through incentives provided by public entities. In France, for example, companies such as Electricité de France, SNCF, Air France and La Poste have committed to acquiring a fleet of 50,000 electric vehicles. In Spain, the bonuses for the purchase of the Toyota Prius hybrid resulted in many taxi companies acquiring many units. These promotion policies will be discussed below. (Sanz Arnaiz, 2015)

Finally, as Andrade (2024) points out, the analysis of the negative effects of excessive production in industries such as tobacco shows that staff cuts can generate more social damage than the adverse effects of high production. This suggests that, in the automotive context, subsidizing production and encouraging sustainable practices could be more beneficial than imposing restrictive taxes, thus allowing an evolution towards greener models without sacrificing jobs. These paragraphs integrate subtle quotes and reinforce the topics discussed in your research on tax strategies and their impact on the automotive industry.

Conclusion

Based on the results obtained, the percentage of taxes or incentives that should be established for the automotive manufacturing industry has been determined. The findings indicate that this percentage is negative, suggesting the need to apply an incentive commensurate with the desired level. Importantly, the automotive industry in Mexico has not yet reached pre-SARS-CoV-2 pandemic production levels, which could justify the implementation of a significant incentive to meet the set targets.

The demand for and supply of electric vehicles has experienced remarkable growth globally. According to García-Espona (2023), 14.1 million electric vehicles (EVs) were sold, including BEVs, HEVs, and PHEVs, representing an increase of 35%. It is anticipated that in 2024 this number will increase by approximately 25%. This growth indicates that the EV market is reaching a maturing phase, having evolved considerably since 2018, when sales were significantly lower.

Amórtegui (2022) points out that both the oil and automotive industries share characteristics such as being capital-intensive, continuously incorporating technology, and presenting an oligopolistic market structure. In particular, the automotive industry is distinguished by its mass production, which allows cost benefits to be obtained thanks to economies of scale. Despite its global nature, where manufacturing and assembly can be carried out in various countries, there is a growing concentration of production in China, which has increased its market share in recent decades.

Mexico, like many other countries, faces difficulties in establishing an effective national innovation system. First, there is no clear understanding of what an innovation system entails; actors tend to act according to their interests, which is aggravated by the lack of guidelines that guide towards a collective goal. Those closer to the market tend to find greater incentives to avoid competition in saturated markets and avoid getting involved in activities that require a high rate of innovation (Unger, 2011).

It is suggested to apply this methodology to each state with a greater presence of automotive manufacturing industries to establish thresholds under local production. In addition, it is vital to consider the cost of the infrastructure needed in Mexico to enjoy the benefits of cars with lower carbon dioxide emissions. Currently, there is no adequate infrastructure to consider electric vehicles as a comfortable and viable option. It is essential to explore models or proposals that allow the most polluting companies to generate a positive impact on the environment, aligning themselves with the international commitments that Mexico has signed. However, it is crucial to note that this objective should not imply that taxes paid by those affected by industrial pollution are used to subsidize these companies in their transition to more sustainable practices, as this would be unfair.

For future research, it is proposed to analyze the phenomenon of nearshoring, which is increasingly attractive for Mexico due to its geographical proximity to the United States. This phenomenon is relevant and raises the need to discuss the convenience of limiting the entry of foreign companies that do not have a sustainable production plan. It is also essential to establish requirements equivalent to the taxes imposed on Mexican factories. There are companies from countries that have not committed to the Glasgow Climate Pact and could seek to enter the country taking advantage of its proximity without complying with the necessary environmental standards. This discussion is essential to guarantee sustainable industrial development in Mexico.

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