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# Tax progressivity and its influence on tax collection levels in Mexico, 1992-2016

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## *ABSTRACT*

This study aims to examine the impact of income tax and VAT progressivity on Mexico's tax collection. In Mexico, tax collection has persistently remained at notably low levels, attributed in part to the perceived inequity within the tax system. Initially, we compute the progressivity of income tax and VAT to ascertain the average percentage increase in these taxes relative to a 100% rise in income. Results indicate income tax's progressive nature, contrasting with VAT's regressive pattern. Subsequently, employing a time-series model, we analyze the influence of income tax and VAT progressivity on tax collection. Our findings reveal a positive correlation between fiscal progressiveness and tax collection levels over both short and long terms. These findings offer practical implications, suggesting that leveraging the insights from this research could fortify tax policies, thereby enhancing tax revenues and contributing to improved income distribution. The analysis underscores the importance of considering the level of progressivity in income tax and VAT rates for enhancing tax collection in Mexico. By leveraging progressive taxation policies, policymakers can potentially boost tax revenues while promoting a more equitable distribution of income. Furthermore, an increase in tax collection can potentially support public programs and services benefiting society as a whole, thus enhancing overall welfare.

**Contribution/Originality:** The research comprehensively examines the influence of income tax progressivity and VAT rates on tax collection in Mexico. Utilizing a time series econometric model with Johansen cointegration methodology and an error correction mechanism, we derive valuable insights for guiding fiscal policy formulation.

## 1. INTRODUCTION

Taxes are monetary or in-kind contributions intended to cover society's public expenses. Their establishment should be fair and governed by fixed rules, and their application should be directed towards expenses that serve the general interest (Ibarra, 2010). However, despite their relevance, collection levels in Mexico are low.

The research gap under consideration highlights the need for a tax reform that aims to increase tax revenues and improve tax equity. Consequently, there is a need for studies that elucidate the factors influencing tax collection, particularly regarding the Income Tax and Value Added Tax (VAT), which constitute the primary federal taxes and form the crux of this investigation.

Historically, Mexico has managed low levels of tax collection, the issue of tax collection has been a part of the problem that continues to be solved. According to measurements made by the Organization for Economic

Cooperation and Development (OECD) (2019) Mexico collected 16.20% of taxes in 2017 with respect to gross domestic product (GDP). It should be noted that social security contributions are encompassed within this percentage; hence, their collection solely from taxes is even lower. The OECD's average total tax collection for the current year was approximately 34.20% of GDP, indicating a 18 percentage point disparity compared to Mexico's total tax collection.

One of the aspects that frame the level of collection are the tax rates (Corbacho, Fretes, & Lora, 2012), which, according to the Political Constitution of the United Mexican States, mandate that taxation be guided by the principles of proportionality and equity (Federal Official Gazette, 2019). Proportionality and equity imply that individuals should contribute to public spending in proportion to their income levels. In other words, for taxation to be equitable, the percentage of tax paid should increase as income increases.

Taxes are an important element in economic and social development, which is why taxpayers play a key role in a country's growth (Bastagli, Coady, & Gupta, 2012). Taxes are the income that the state receives through contributions that are legally required and that serve the government to fulfill its public function, that is, to cover collective needs (Lara, 2009). A country's tax policy is an essential component of its fiscal policy framework. Beyond enhancing economic efficiency, it holds significant importance in income distribution. Thus, the primary objective of tax policy should be to secure greater economic resources to fulfill the requirements of public spending, recognizing this as a fundamental necessity for every nation (Sarur & Romero, 2018).

For Jiménez and Podestá (2017) there are three factors that have prevented a better performance in the collection of income tax: the reduction of rates, the applications of exemptions and deductions, and the high levels of evasion. In this regard, the maximum income tax rate for individuals in Mexico decreased from 55% to 35% during the period 1981-2019 (Federal Official Gazette, 2019). Although for these authors tax evasion is one of the factors inlow-income tax collection, Trigueros and Fernández (2001) consider it in the case of VAT. Aguilar (2014) mentions that VAT, by its nature, is already a regressive tax, but with increases in the general rate, the perception of its regressivity increases. For CEPAL (2017) the decision of taxpayers on non-compliance, in whole or in part, of their tax obligations is related to the fragility of the tax pact. Tello and Hernández (2010) indicate that fiscal policy in Mexico has been based on a wrong diagnosis about the behavior of taxpayers.

One of the factors explaining a country's tax collection capacity is the taxpayer's perception of the actors and structure within the tax system. In terms of enhancing equity, fiscal policy should take into account the progressivity or regressivity of taxes. Indirect taxes, being regressive, impose a uniform tax rate on all consumption irrespective of individuals' income levels, exacerbating inequality, particularly as high-income sectors also benefit from tax exemptions (CEPAL, 2017). In the study carried out by Gómez (2006) he observed that tax regulations affect the results obtained in terms of income distribution, because the established taxes, in general, do not contemplate the principle of both horizontal and vertical equity.

The structure of tax establishments in Mexico has been criticized by various authors as a determinant of the low level of tax collection, particularly in terms of fiscal equity. Consequently, this research aims to address two main objectives. Firstly, it seeks to measure the levels of fiscal equity by assessing the progressivity of taxes through their elasticity, i.e., examining variations in tax payable in response to changes in income. Secondly, it aims to explore the relationship between tax progressivity and tax collection levels. This approach allows for an examination of the extent to which fiscal equity influences tax collection. The hypothesis posited is that there exists a positive relationship between the level of tax collection and the progressivity of both the Income Tax and VAT.

The significance of this study lies in the recognition that tax collection is a critical factor in helping countris accquire sufficient income for their development. Mexico, in particular, must foster growth and formulate social policies aimed at enhancing the living standards of its citizens and alleviating poverty. To achieve this objective, it is imperative to fortify tax collection mechanisms by enhancing the efficiency of the tax system (Organization for Economic Cooperation and Development (OECD), 2019).

There are five sections in this article. It commences with an introduction. The second section encompasses a literature review on tax collection and its determinants. The third section delineates the materials and methods to be utilized for the research, divided into two parts: firstly, the methodology for measuring fiscal progressiveness in Mexico, and secondly, the methodology for exploring the relationship between variables. The presentation of the results and discussion follows, with the main conclusions highlighted.

## 2. LITERATURE REVIEW

Since the time of the mercantilists, studies on taxation were already beginning, such as in the case of Petty (1662) who considers taxes as something necessary to cover public offices: the defense, the maintenance of governments, the schools and universities, and the maintenance of orphans, among others. Later, Smith (1776) divided the sovereign's expenses into three parts: defense expenses, justice expenses, and expenses for works or political institutions. To cover these expenses, the sovereign must collect taxes, for which four basic principles are established: equality, certainty, convenience, and economy.

Ricardo (1817) considers that taxes are a portion of the product of the land and labor of a country given to the government, and all of them tend to diminish the power of accumulation. Mill (1848) makes taxes seen as a sacrifice that the citizens of a country must make to sustain government expenditures. In view of this, he states that in matters of taxes, the principle of equality must always prevail, since he considers that the sacrifice of citizens should be for everyone equally, so that the sacrifice for the whole is less.

More recent authors, such as Stiglitz (2000) establish five principles that taxes must contain for him: economic efficiency, administrative simplicity, flexibility, political responsibility, and justice.

According to Samuelson and Nordhaus (2006) taxes are the main source of income available to states to pay for public programs. For this reason, taxes must contain the following principles: the principle of profit, the principle of the ability to pay, and the vertical and horizontal equity principle.

The Laffer Curve, which originated from Arthur Laffer's proposition, is another aspect of tax collection that has undergone examination. It posits that the level of collection is a function of the tax rate, premised on the notion that initially, as the tax rate rises, tax collection increases until reaching an optimal point. This point represents the maximum rate of taxation that society is willing to bear. Beyond this optimal point, tax collection diminishes as the tax rate continues to increase (Wanniski, 1978).

This theory on the relationship between tax collection and tax rate has become susceptible to different criticisms since, for authors such as Tanzi (2014) the Laffer curve lacks realism since it does not consider the reactions of taxpayers and other variables that influence the collection; likewise, Fedeli and Forte (2013) have considered it a fiscal illusion. Given the criticism of the Laffer curve theory, it is important to analyze how taxes should be established. For this, the principles that taxes should contain are dictated by Smith (1776); Stiglitz (2000) and Samuelson and Nordhaus (2006).

Taxpayers view a tax system as unequal, which encourages tax evasion and reduces government revenues (Spicer & Becker, 1980). Whereas, a tax policy with a progressive (equitable) tax system influences income distribution (Gómez, 2006; Kakwani & Hyun, 2022; Kakwani & Son, 2021; Kang, 2019; Stantcheva, 2020; Zheng et al., 2020). On the other hand, according to Samuelson and Nordhaus (2006) and Balan, Bergeron, Tourek, and Weigel (2022) income redistribution must occur through tax collection and spending policies, although they do not rule out that sometimes regulation also plays an important role. In this way, a fiscal policy based on tax equity has a double effect: on the one hand, the perception of equity helps to increase collection, and, on the other, fiscal equity reduces the degree of inequality in the countries.

Continuing with the relationship between tax collection and tax rate, and adding that said rates must be established with equity, the tax revenues are analyzed based on the level of equity of the tax rates. In this regard, Alstadsæter, Johannesen, and Zucman (2019); Doerrenberg and Peichl (2013); Basri, Felix, Hanna, and Olken

(2021); Rubolino (2023), and Rubolino and Waldenström (2020) verify that tax progressivity affects the tax morale adopted by citizens of a country, this same incidence was worked on by Castañeda (2017), obtaining a positive relationship. Finocchiaro and Rizzo (2014) andPapanikolaou (2021), through econometrics, showed that when people are in a condition of inequity, they are significantly more likely to evade taxes than in conditions of equity.

Murphy, Chistensen, and Kimmis (2005); Bachas, Gadenne, and Jensen (2020)and Mukherjee and Badola (2023) consider that tax justice is a primary factor for the state to obtain income from taxes. Pérez (2014) estimates that through an increase in horizontal equity, it is possible to improve collection efficiency. Brockmeyer, Estefan, Arras, and Serrato (2021); Hlasny (2021) and likewise& Chávez (2001) have argued that, for Mexico, it is possible to achieve an increase in collection through a progressive increase in income tax for companies and high-income sectors, increasing new income tax lines and making rates more equitable.

Trigueros and Fernández (2001) make some proposals regarding collection in Mexico, the main one being to increase the tax base through the reduction of tax exemptions in the case of VAT and, in the case of income tax, the reduction of the salary credit. In such a way that it is guaranteed that only those people with income equivalent to a minimum wage are exempt from paying income taxand modify the income tax rate so that it is less progressive at low-income levels, this is to increase the collection by making the tax system more equitable.

## 3. MATERIALS AND METHODS

The methodology presented in this research is divided into two parts; in the first, the progressivity of the income tax rates for individuals and VAT is calculated, and in the second instance, an econometric model of time series is developed to know the relationship between the level of collection and the progressivity of income tax and VAT rates.

### *3.1. Variables*

Based on the theoretical-empirical analysis, which seeks to validate the relationship that the levels of tax progressivity have with tax collection in Mexico, the following variables are established:

Dependent: Level of tax collection;

Independent: Level of progressivity of income tax rates and level of progressivity of VAT rates.

Dependent variable: level of tax collection.

In the case of the dependent variable, it is not necessary to resort to methodologies because its data will be obtained from the System of National Accounts, acquiring data on tax collection and GDP since the aim is to know tax revenue as a percentage of GDP. In this way, the level of collection will be measured, considering, implicitly, the level of economic activity, as it is one of the largest components in terms of tax collection. Therefore, we propose addressing the level of tax collection using the following expression:

Tax Collection Level = Tax Collection / GDP

Since income tax and VAT are the two taxes under consideration, we measure the level of collection as a percentage of GDP.

Independent variables: level of progressivity of income tax and level of VAT progressivity.

In the case of independent variables, the process to obtain them is a little longer since the data is not available and, therefore, it is necessary to calculate it. Based on empirical evidence from previous studies, it is proposed to calculate the difference that exists between the concentration of income levels and the concentration of tax payments with respect to income levels. To measure the progressivity of taxes, it is necessary to know how the tax payable increases as the level of income increases.

### *3.2. Progressivity of IncomeTax and VAT Taxes*

The progressivity of rates is a factor that has been measured for a long time. Within the literature, it can be found that the main methodologies used to measure the progressivity of taxes have been the following:

- Propensity for medium rates. Proposed by Slitor (1948) themeasures the progression of the tax rate as the difference between effective and marginal rates, divided by income before taxes.
- Kakwani index. Proposed by Kakwani (1977) it consists of the difference between the Gini coefficient before taxes and a quasi-Gini that he proposes. This quasi-Gini involves calculating the tax distribution in the same manner as the Gini coefficient calculates the income distribution.
- Reynolds and Smolensky index. Proposed by Reynolds and Smolensky (1974) the measure of fiscal progressivity is the difference between the Gini coefficient before and after taxes.

Within the empirical evidence, there are also studies carried out by Zapata and Ariza (2005) who analyze the progressivity of VAT and ISR taxes on the consumption of liquors and beers, cigarettes, and tobacco in Colombia with the Kakwani and Reynolds indices and Smolensky. For their part, Barreix, Roca, and Villela (2006) use the Kakwani index. The authors Huesca and Serrano (2005) and Hanni, Martner, and Podestá (2015) use the propensity of average rates, the Kakwani index, and the Reynolds and Smolensky index.

Measuring progressivity through the propensity of average rates, the Kakwani index and the Reynolds and Smolensky index, have generated valuable information on how progressive taxes become and, above all, how they influence redistribution. of income. However, what this research seeks is to know the variations that the real tax payable presents in the face of a certain variation in income; therefore, it is proposed to measure fiscal progressivity in the form of elasticity (Conejo, Otoya, & Cardoza, 2011) that is to say, to know the average increase in the tax before an increase of one hundred percent of income. The proposal is as follows:

The initial step involves acquiring data on various levels of income and expenses. To achieve this, the proposal suggests utilizing statistical data from INEGI, specifically the National Survey of Household Income and Expenditure (ENIGH), spanning from 1992 to 2016. The sections on income and expenses distinguish between monetary and non-monetary categories. For this study, only monetary data will be utilized, as non-monetary aspects hold no relevance in fiscal matters. Additionally, it's crucial to highlight that the income presented by the ENIGH is post-tax. Consequently, many investigations utilizing indices such as Kakwani or Reynolds and Smolensky carry out supplementary procedures to eliminate the tax effects and approximate the pre-tax income.

This is not the case of the present investigation because it is intended to know the level of increase in the tax to be paid with respect to a certain level of increase in income; therefore, in this investigation, the income levels shown by the ENIGH without any transformation.

Since the ENIGH is published every two years, there are no data for all the years of study, therefore, for the years in which there are no data (1993, 1995, 1997, 1999, 2001, 2003, 2007, 2009, 2011, 2013, and 2015), the income levels will be calculated as half of the difference between the immediately preceding year and the immediately following year. Given the changes to the ENIGH methodology starting in 2017, the index construction loses continuity for subsequent years; this inconsistency forces us to work only until 2016.

The second step is to have the tax legislation (VAT Law and Income Tax Law) in force for each of the years of the study period.

The third step is to calculate the taxes for each of the income levels in each of the years of the period studied.

The next step is to calculate the progressivity of taxes through their elasticity, which is carried out as follows:

a) It is necessary to know the income growth rate of each of the deciles in relation to the first decile and, in the same way, calculate the growth rate of the tax to be paid for each income level with respect to the first decile.
b) We obtain an arithmetic mean of growth rates of both income and tax.
c) Finally, the average income growth is divided by the average growth of the tax, in this way, the result is the average tax increase in the face of a 100% increase in income.

We obtain tax progressively index using the methodology so far described.

### *3.3. Econometric Model of Time Series: Relation of Tax Collection - Progressivity of Income Tax and VAT*

Tax collection has been studied through a large number of investigations under various methodologies among them is the use of econometrics, to name a few. It is possible to mention (Kenny & Winer, 2006) who study the relationship between tax revenues and tax base using an econometric model; Castañeda (2017) works on a Tobit and Probit model to measure the existing relationship between tax morale and tax progressivity; Doerrenberg and Peichl (2013) based on a binary regression model, analyze the causality of the progressivity of taxes on tax morale; Conejo et al. (2011) with time series, validate tax revenues as a function of GDP; and, Sen (2007) use a panel data model to know the relationship between fiscal income and per capita GDP, corruption, and direct and indirect taxes.

It is proposed here to carry out an econometric model of time series to identify the relationship that exists between tax collection and the progressivity of taxes during the period 1992-2016. When looking at the time series models in econometrics, one problem is that there may be a trend component or persistent innovations in the process between variables of a regression model. This can make the asymptotic theory and the sampling distributions of estimators obtained by ordinary least squares (Granger & Newbold, 1974).

In conducting econometric estimates, understanding the behavior of the series is essential to ascertaining whether they are stationary. Analyzing stationarity in estimation is a standard practice because failure to adhere to this behavior can yield estimation results with inaccurate parameters in economic relationships. The work of Granger and Newbold (1974) provides an answer to the problem of regressions with false or spurious causal relationships, since they propose a method to verify whether the integrated variables are cointegrated, in which case the regression results are not spurious.

This allows you to distinguish between a false relationship and one that is not. The studies by Granger (1983) and Engle and Granger (1987) analyze the issue of cointegration in the variables, which establishes that two integrated variables of order I (1) cointegrate or converge in the long term and that the divergences in the short term can be captured through the Error Correction Mechanism (MCE).

Dickey and Fuller (1979) and Dickey and Fuller (1981) propose a test to analyze the unit root presented by the series and thus determine the order of integration. Regressions estimated under the following forms apply to the test.

$$\Delta Y_t = \beta_1 + \delta Y_{t-1} + u_t \qquad (1)$$

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + u_t \qquad (2)$$

In the second case, $t$ is the time or trend variable, with the null hypothesis being that $\delta = 0$, that there is a unit root.

The Augmented Dickey-Fuller (ADF) test is a version of the Dickey-Fuller test for much larger and more complicated time series models. The ADF is a negative number, the larger the negative number in the ADF statistic, the stronger the rejection of the null hypothesis about the existence of a unit root or non-stationarity.

The regression equation is based on the previous regressions but augmented with lagged terms of the variable.

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \Upsilon \sum_{i=1}^{p} Y_{t-i} + u_t \qquad (3)$$

In the present investigation, the unit root test is carried out on each of the variables, using the Augmented Dickey Fuller test, to determine the order of integration of the variables since, in the case of cointegration, it is sought that the variables have a degree of integration of the first order I (1). The Johansen methodology performs the cointegration analysis after the unit root test.

In order to perform the cointegration model, the series that are integrated of order I (1) are taken, and the Vector Auto Regressive (VAR) model is carried out. Autoregressive vectors (VARs) were introduced into empirical economics by Sims (1980) who showed that these vectors provide a flexible and tractable framework for the analysis of time series. A VAR is a linear model of n variables where each variable is explained by its own lagged values, plus

the past values of the rest of the variables. People often use VARs to predict interrelated time series systems and to analyze the dynamic impact of random shocks on the system of variables. The starting point for carrying out the VAR model is to determine the number of lags. The optimal lag is essential because it is the basis for calculating the number of cointegration vectors. We will use the following tools in this study to select the optimal lag.

LR Statistics: Probability Ratio Statistics.

AIC Criteria: Akaike Information Criteria.

SC: Schwarz Information Criterion.

HQ: Hannan Quinn Information Criteria.

FPE: Final Prediction of the Error.

We present the autoregressive model after determining the lags.

Reduced form of VAR:

$$X_t = \mathrm{A}_1 X_{t-1} + \cdots + \mathrm{A}_p X_{t-p} + \mathrm{B} X_t + \varepsilon_t \qquad (4)$$

Where:

$X_t$ = Is a vector (Nx1) of integrated endogenous variables of order one, which are denoted I(1)

$\mathrm{A}_1, \ldots, \mathrm{A}_p$, y B = Are matrices of coefficients to be estimated.

p = Is the number of lags included in the VAR.

$\varepsilon$ = Is (Nx1) of normally and independently distributed error terms.

After performing the VAR model with the optimal numbers of lag, we carry out the Johansen cointegration test to determine the relationship between the long-term variables. For Engle and Granger (1987) the long-term equilibrium between a set of variables is defined as:

$$\beta_1 X_{1t} + \beta_2 X_{2t} + \cdots + \beta_n X_{nt} = 0 \qquad (5)$$

The components of the vector $X_t$ are integrated in order $d$ and exists a vector $b = (b_1, \ldots b_n)$ in which the combination is linear. For Johansen (1988) cointegration offers a synchronization in time that reflects a reliable relationship between the variables. Johansen assumes that in the model all the variables are endogenous and that the series are integrated in the same order I(d). To test the existence of the number of cointegration vectors (r) between the variables, two statistics based on the maximum likelihood test are applied in order to determine the cointegration range of the system: the trace test and the maximum value test. Note that both tests should yield identical results for a comprehensive conclusion.

The trace test (λtrace)

$$\lambda_{trace} = \sum_{i=r+1}^{N} \ln(1 - \hat{\lambda}_i) \qquad (6)$$

Where:

$\hat{\lambda}_i$= They are the eigenvalues.

N= It is the number of endogenous variables.

The test of maximum eigenvalue (λmax).

$$\lambda_{max} = -T ln(1 - \hat{\lambda}_\iota) \qquad (7)$$

Where:

$\hat{\lambda}_i$= They are the eigenvalues.

T= It is the number of observations minus the number of lags.

Finally, after having performed the cointegration test, if it is concluded that the variables cointegrate, that is, they have a long-term equilibrium, then it is feasible to perform the Vector Error Correction (VEC) model for the relationship between the variables in the short term.

The VEC model is a type of VAR model for variables that are stationary in their first differences and are expressed as a linear function of past values of themselves (lags), past values of the rest of the variables in the model, and of the cointegration vectors (Engler & Nahuelhual, 2003). According to Granger's Representation Theorem, the VEC model expresses the relationship between two cointegrated (Gujarati & Porter, 2010).

$$\Delta Y_t = m + \lambda ECq + \sum_{i=1}^{p-1} R_i \, \Delta Y_{t-1} + u_t \quad (8)$$

$$R_i = -\left(I - A_1 - A_2 - \cdots - A_p\right); (i = 1,2, \ldots, p-1) \quad (9)$$

Where:

$\Delta Y_t$ = Differentiated vector of endogenous and integrated variables of order I(1).

$\Delta Y_{t-1}$ = Delayed differentiated vector of endogenous variables.

$ECq$ = Error correction term and cointegration equation.

$R_i$ = Dynamic parameters of lagged variables.

λ= Balance adjustment parameter speed.

m = Constant.

$u_t$ = Error term.

Once the model has passed all the above tests, the Cholesky normality, Autocorrelation and Homoscedasticity tests are carried out with and without cross terms.

## 4. RESULTS AND DISCUSSION

The results are addressed in two subsections. The first is the progressivity of the income tax rates and VAT. In the second subsection, the results of the econometric model with time series are found.

### *4.1. Progressivity of Income and VAT Taxes*

The results are outlined below, beginning with an examination of the progressivity of the income tax. The analysis initially involved measuring the income growth rates for each income level relative to the initial level. Following this, the corresponding tax obligation for each income bracket was calculated, enabling the determination of tax growth rates. Subsequently, the average growth rates for both income and income tax were computed, utilizing an arithmetic mean, based on the percentage increases obtained for each income level.

The results show that when the income grows, it increases, but in a smaller proportion. In the years 1992, 1993, and 1994, the highest average percentage of increase was observed between the income levels, with values of 966.61%, 951.21%, 939.04%, respectively. However, despite the high levels of increase in income, the percentage of growth in the payment of the tax barely reaches values of 148.76%, 138.44%, 144.92%, respectively (see Figure 1).

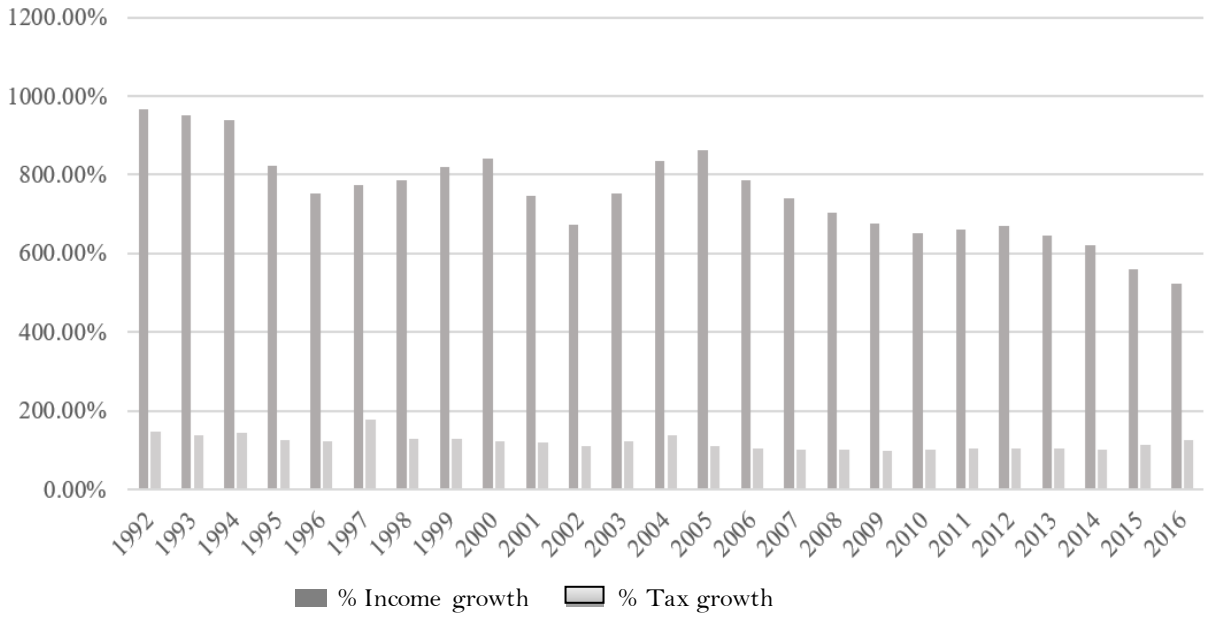


**Figure 1.** Income and tax growth.

**Source:** Own elaboration based on the national institute of geography and statistics: National household income and expenditure survey, (1992, 1994, 1996, 1998, 2000, 2002, 2004, 2005, 2006, 2008, 2010, 2012, 2014, 2016) and Federal Official Gazette(1991, 1994, 1995, 1996, 1998, 2000, 2002, 2004, 2007, 2008, 2009, 2012, 2014, 2015 y 2016).

With the average growth levels of income and payment of Income Tax observed in Figure 1, the progressivity measurement was carried out, measuring it as elasticity. The results show positive numbers, indicating that the Income tax is a progressive tax, having an average value of 0.1621 in the period; that is, if income increases 100%, the tax rate payable with respect to income increases on average by 16.21%.

During the period under analysis, it is evident that the years exhibiting the highest levels of progressivity in the Income Tax were 1997 and 2016, with indices of 0.2290 and 0.2410, respectively. This indicates that in 1997, for every 100% increase in income, the tax payment rose by 22.90% relative to the income. Similarly, in 2016, the Income Tax increased by 24.10% for every 100% rise in income. Conversely, when examining the lowest levels of progressivity, the years with the lowest indices were 2005, 2006, and 2007, with values of 0.1280, 0.1346, and 0.1371, respectively. This implies that for each 100% increase in income, the Income Tax increased by an average of 12.80% in 2005, 13.46% in 2006, and 13.71% in 2007. (see Figure 2).

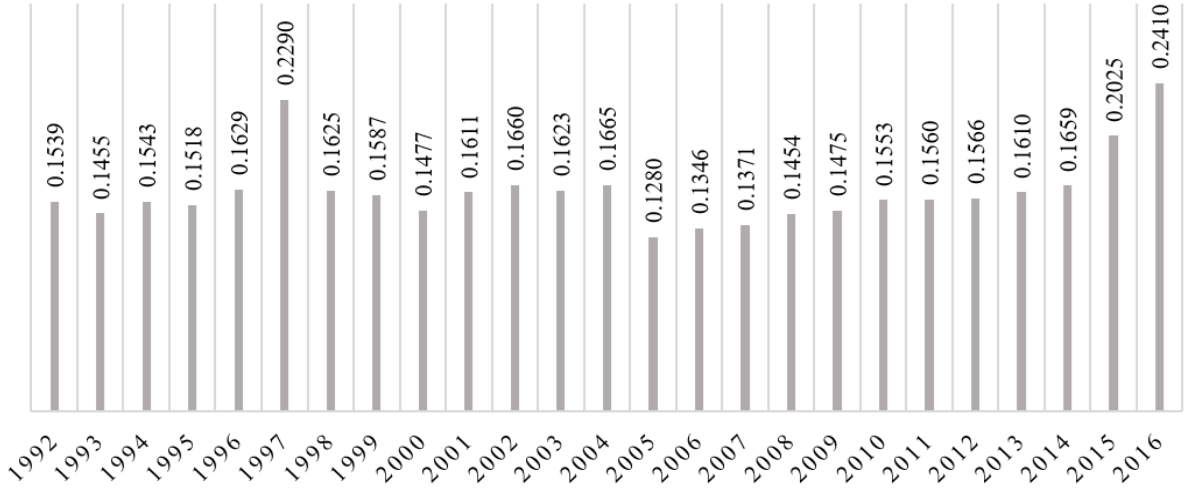


**Figure 2.** Income tax progressivity index.

**Source:** Own elaboration based on the national institute of geography and statistics: National household income and expenditure survey, (1992, 1994, 1996, 1998, 2000, 2002, 2004, 2005, 2006, 2008, 2010, 2012, 2014, 2016) and official gazette of the federation (1991, 1994, 1995, 1996, 1998, 2000, 2002, 2004, 2007, 2008, 2009, 2012, 2014, 2015 and 2016).

The methodology for VAT analysis computed the total tax payable as a percentage of total income, not just monetary income. This approach acknowledges that individuals base their expenditures on their total received income, irrespective of whether it is monetary or taxable.

Similar to the calculation method used for the progressivity of Income Tax, the analysis of VAT progression also begins with computing the growth averages among various income levels and the corresponding growth averages of VAT payments relative to income. Notably, for VAT, total income serves as the reference point. For instance, we observed the highest percentage increase in income between different levels in the year 2000, reaching 621.36%. Conversely, the year 2006 recorded the lowest average percentage increase in income during the 1992-2016 period, standing at 372.14%, representing 59.89% in comparison to the year 2000. (see Figure 3).

In examining the VAT, it was noted that unlike the Income Tax, VAT does not exhibit increases as income rises. Conversely, we observed a decrease in VAT payable relative to income as income increases, suggesting a regressive tax structure. Figure 3 illustrates that in 2010, the most significant reduction in tax relative to income occurred, reaching a value of -39.22%. Conversely, the smallest decrease was observed in 2006, with a value of -1.88%.

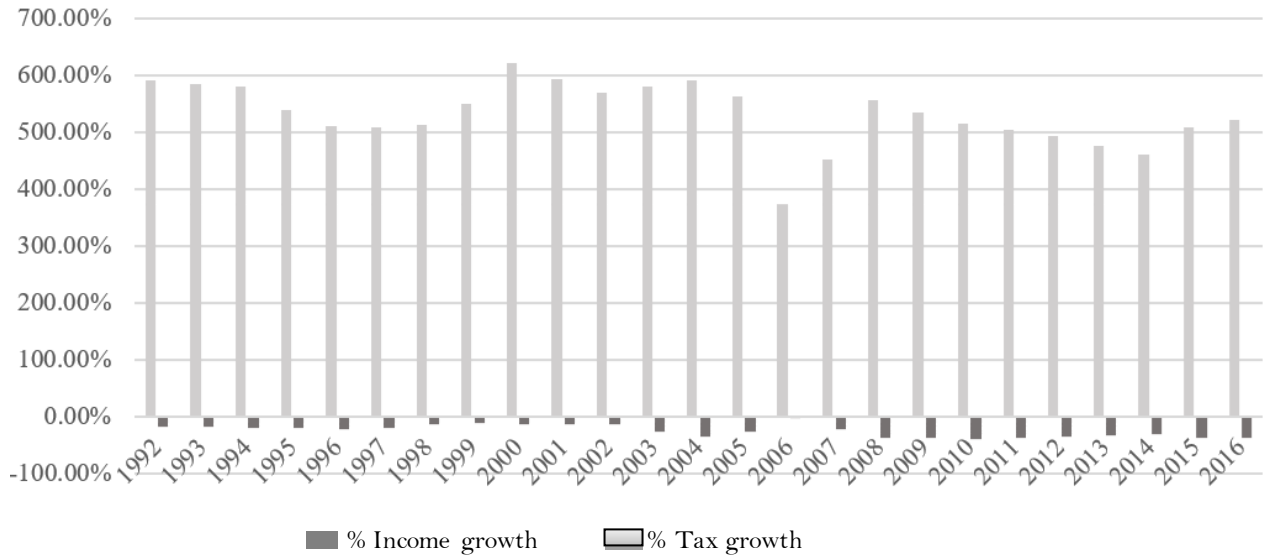


**Figure 3.** Income and VAT growth.

**Source:** Own elaboration based on the national institute of geography and statistics: National household income and expenditure survey, (1992, 1994, 1996, 1998, 2000, 2002, 2004, 2005, 2006, 2008, 2010, 2012, 2014, 2016) and official gazette of the federation (1991, 1995, 2009 and 2013).

We can now measure progressivity based on the aforementioned data, finding an average of -0.0471. This indicates that when income increases by 100%, the percentage of VAT payable relative to income decreases on average by 4.71%. These findings highlight that the most favorable year was 2006, with a value of -0.0050, reflecting the lowest regressivity within the period. This suggests that for each 100% increase in income, the tax decreases by an average of 0.5%. Conversely, the year 2010 exhibits the highest regressivity, recording a value of -0.0761. In other words, when total income increases by 100%, the percentage of VAT payable relative to income decreases by 7.61%.In Figure 4, it is possible to observe that in the period 2008-2016, the highest levels of regressivity obtained from 1992-2016 were maintained.

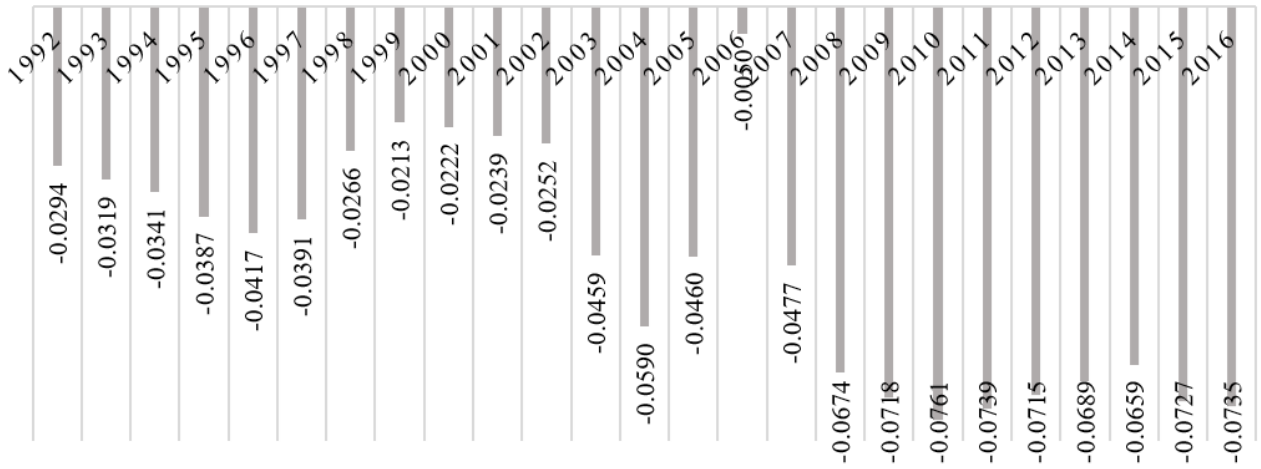


**Figure 4.** VAT progressivity index.

**Source:** Own elaboration based on the national institute of geography and statistics: National household income and expenditure survey, (1992, 1994, 1996, 1998, 2000, 2002, 2004, 2005, 2006, 2008, 2010, 2012, 2014, 2016) and official gazette of the federation (1991, 1995, 2009 and 2013).

The next step to take is to know the levels of collection obtained by the concepts of Income Tax and VAT, that is, of the two taxes that are being worked on. In the period, there was an average income tax and VAT collection of 7.31% as a percentage of GDP, with 1995 being the year that showed the lowest level of income from Tax Income and VAT, and 2016 with the highest collection percentage (see Figure 5).

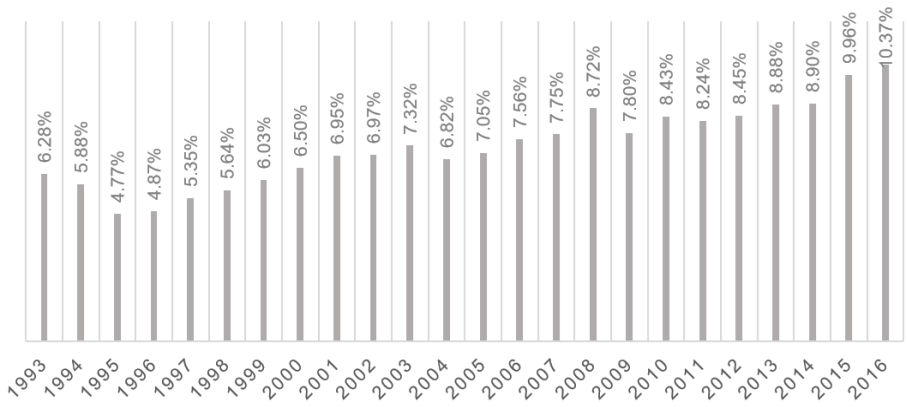


**Figure 5.** Income tax and VAT collection with respect to GDP.

**Source:** Own elaboration based on the system of national accounts (2018) and Sistema de Administración Tributaria (SAT) (2018).

### *4.2. Results of the Time Series Econometric Model: Relation of Tax Collection - Progressivity of Income Tax and VAT Taxes*

Next, the time series econometric model is developed, where the level of income tax and VAT collection is taken as the dependent variable with respect to GDP and, as independent variables, the progressivity indexes of the Income taxand VAT that were calculated in the previous section for the period 1992-2016. It begins with the Augmented Dickey Fuller unit root tests for the variables Income tax and VAT, Income Tax progressivity index and VAT progressivity index, first performing the level tests (see Table 1), resulting in prob values of 0.9818, 0.4942, and 0.4734, respectively, which indicates that the null hypothesis of the three variables is accepted, therefore at the level they present unit root. The tests are carried out again, but now with their transformation to first differences, where the three variables with prob values of 0.000, 0.000, and 0.001, respectively, show to be stationary, so they were all significant at 1%. In these results, it is observed that the variables have a degree of integration I (1); therefore, now it is certain to be able to work with the data in a cointegration model.

**Dependent Variable:**

Y =The level of income tax and VAT with respect to GDP

**Independent variables**

PI IT = Progressivity indexes of the income tax

PIVAT = Progressivity indexes of VAT

**Table 1.** Augmented Dickey-Fuller unit root test.

| **Augmented Dickey-Fuller unit root test** | | | | |
|---|---|---|---|---|
| **Variable** | **Level** | | **Firstdifferences** | |
| | **Statistical** | **Probability** | **Statistical** | **Probability** |
| Y | 0.480 | 0.982 | -5.143 | 0.000 |
| PI IT | -1.545 | 0.494 | -5.387 | 0.000 |
| PIVAT | -1.587 | 0.473 | -4.769 | 0.001 |
| Augmented Dickey-Fuller unit root test | | | | |
| Variable | Level | | Firstdifferences | |
| | Statistical | Probability | Statistical | Probability |
| Y | 0.480 | 0.982 | -5.143 | 0.000 |
| PI IT | -1.545 | 0.494 | -5.387 | 0.000 |
| PI VAT | -1.587 | 0.473 | -4.768 | 0.001 |
| Augmented Dickey-Fuller unit root test | | | | |
| Variable | Level | | Firstdifferences | |
| | Statistical | Probability | Statistical | Probability |
| Y | 0.480 | 0.982 | -5.143 | 0.000 |
| PI IT | -1.545 | 0.494 | -5.387 | 0.000 |
| PI VAT | -1.587 | 0.473 | -4.769 | 0.001 |

Subsequently, to carry out the VAR model, the selection criteria test of the number of lags is carried out, where, it is observed that the optimal lags determined by the statistics and criteria LR, FPE, AIC, SC, and HQ with which to work are 1, so it starts with the cointegration model with a lag (see Table 2).

**Table 2.** Definition of the optimal lag.

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 170.429 | NA | 4.92e-11 | -15.221 | -15.072 | -15.186 |
| 1 | 203.751 | 54.527* | 5.46e-12* | -17.432* | -16.837* | -17.292* |
| 2 | 210.147 | 8.721 | 7.32e-12 | -17.195 | -16.154 | -16.950 |

**Note:** * Indicates the order of lags selected by the criterion.
LR: Modified sequence LR statistical test (Each test at the level of the 5%).
FPE: Final error prediction.
AIC: Akaike information criteria.
SC: Schwarz information criterion.
HQ: Hannan-Quinn information criterion.

When developing the VAR model with a lag and applying the Johansen cointegration test to it, it can be observed that both in the trace cointegration test and in the maximum eigenvalue test, the null hypothesis is rejected and none of the variables cointegrate when obtaining prob values of 0.000 (see Table 3). When passing to the next range, the null hypothesis is accepted because at least one of the variables cointegrates with Prob values of 0.353 and 0.183 in both tests, respectively, so it is said that the variables cointegrated in range 1 -because that is the range where the null hypothesis is accepted for the first time. It is important to highlight that it is also shown in Table 3, that at least two variables cointegrate. These results together give evidence that there is cointegration between the variables, that is, that the variables have long-term equilibrium.

**Table 3.** Johansen cointegration test.

| Series: YPI IT PI VAT | | | | |
|---|---|---|---|---|
| Interval lags (In first difference):1 to 1 | | | | |
| Unconstrained cointegration range test (Trace) | | | | |
| **Hypothesized cointegration equation No. (s)** | **Own value** | **Trace statistic** | **0.05 critical value** | **Prob value **** |
| None* | 0.891 | 66.610 | 42.915 | 0.000 |
| At least 1 | 0.499 | 17.859 | 25.872 | 0.353 |
| At least 2 | 0.114 | 2.658 | 12.518 | 0.915 |
| The trace test indicates 1 equation cointegrates to the level 0.05 | | | | |
| Unconstrained cointegration range test (Maximum eigenvalue) | | | | |
| Hypothesized equation no. cointegration (s) | Own value | Statistical maximum value own self | 0.05 Value critical | Prob value ** |
| None* | 0.891 | 48.751 | 25.823 | 0.000 |
| At least 1 | 0.499 | 15.201 | 19.387 | 0.183 |
| At least 2 | 0.114 | 2.6582 | 12.518 | 0.915 |
| The maximum eigenvalue test indicates 1 equation cointegrates at the 0.05 level | | | | |

**Note:** * Denotes rejection of hypotheses at the level 0.05.
** MacKinnon, Haug, and Michelis (1999) p-valor.

Table 4 displays the cointegration equation, wherein the normalized cointegration coefficients, interpreted as elasticities, were derived with the appropriate signs. For the Income Tax progressivity index, a coefficient of -0.096 was obtained, and for the VAT progressivity index, the coefficient was -0.395. These findings reveal a positive relationship between the variables, signifying that higher income tax progressivity corresponds to increased tax collection, and higher VAT progressivity correlates with elevated tax collection. To be precise, a 100% variation in the level of income tax progressivity results in a 9.57% increase in income tax collection, while a 100% increase in VAT progressivity leads to a 39.5% increase in VAT collection. It's worth noting that VAT is regressive, meaning that an increase in progressivity implies a reduction in regressivity (see Table 4).

**Table 4.** Cointegration equation.

| 1 Cointegration equation: Log probability 223.1685 | | | |
|---|---|---|---|
| Normalized cointegration coefficient (Standard error in parentheses) | | | |
| **Y** | **PI IT** | **IP VAT** | **´@TENDENCIA (93)** |
| 1.000 | -0.096<br>(0.031) | -0.395<br>(0.041) | -0.003<br>(0.000) |

To comprehend the short-term dynamics in relation to the long-term relationship, the approach of Engle and Granger (1987) was adopted, wherein the Error Correction Vector (VEC) model was constructed. This model is devised to delineate the connection between the equilibrium analysis over the long term and the adjustment dynamics over the short term, serving as a mechanism to rectify deviations from equilibrium and prevent long-term errors from escalating. In the VEC results, a coefficient of -0.835815 (negative and less than unity) was obtained, indicating that deviations between the short and long term are rectified by 83.58% within a one-year period, i.e., annually. Furthermore, the VEC exhibits a T statistic of -6.7374 (greater than -2), signifying the significance of the coefficients presented and thereby validating the preceding statements (see Table 5).

Regarding the interplay between the variables, it is evident that the only variables with significant coefficients in the short term are income tax and VAT collection as a percentage of GDP, coupled with the lagged VAT progressivity index, which exhibits a T statistic of -3.3690, thus confirming its significance. The coefficient obtained holds a value of 0.1781, indicating a positive relationship between the levels of income tax and VAT collection and the rate of VAT progressivity (see Table 5).

**Table 5.** Error correction mechanism.

| **Error correction:** | **D(Y)** | **D(IP IT)** | **D(IP VAT)** |
|---|---|---|---|
| CointEq1 | -0.836<br>(0.124)<br>[-6.738] | 0.056<br>(1.142)<br>[-0.049] | -0.803<br>(0.668)<br>[1.202] |
| D(Y (-1)) | 0.224<br>(0.125)<br>[-1.791] | -0.489<br>(1.153)<br>[0.423] | -0.074<br>(0.675)<br>[0.110] |
| D(IP IT(-1)) | 0.029<br>(0.028)<br>[-1.056] | 0.237<br>(0.256)<br>[-0.926] | 0.106<br>(0.150)<br>[-0.706] |
| D(IP VAT(-1)) | 0.178<br>(0.052)<br>[-3.369] | 0.157<br>(0.487)<br>[-0.322] | -0.142<br>(0.285)<br>[0.499] |

To validate the results of the model, tests for Normality, Autocorrelation, and Homoscedasticity were conducted. We employed the Cholesky normality test to determine the normality of the residuals. The null hypothesis (Ho) states that the residuals have a normal distribution. The obtained result had a probability value of 0.4641. Given this result, it indicates that the residuals of the model are normally distributed, thus the model successfully passes the normality test. (see Table 6).

**Table 6.** Residual tests.

| **Test** | **Prob. value** |
|---|---|
| Cholesky normality | 0.464 |
| Autocorrelation | 0.756 |
| Homoscedasticity without cross terms | 0.717 |
| Homoscedasticity with cross terms | 0.174 |

Regarding the autocorrelation test, where the null hypothesis (Ho) asserts the absence of autocorrelation in the model, Table 6 illustrates that the probability value obtained was 0.7556. This indicates no presence of autocorrelation among the variable values.Subsequently, homoscedasticity tests were conducted both without crossed terms and with crossed terms. The null hypothesis (Ho) states that the variance of the errors is homoscedastic. The results showed a probability value of 0.7171 for the test without crossed terms and a value of 0.1738 for the test with crossed terms. These outcomes suggest that the model exhibits homoscedasticity. (see Table 6).

Upon confirming that the model successfully passes the tests for normality, autocorrelation, and homoscedasticity of the residuals, it can be concluded that the interpretations made regarding the model are statistically acceptable.

The results validate the relationship between tax collection and tax rate progressivity. This underscores the necessity to enhance levels of fiscal equity through fiscal reforms aimed at improving tax progressivity. Consequently, increased tax revenues will enable the state to furnish better services to citizens. Furthermore, enhanced fiscal progressivity will play a pivotal role in income redistribution.

### *4.3. Discussion*

Several works have been carried out to analyze the problem of tax collection as well as the high levels of fiscal inequality, addressing them with different methodologies such as those proposed by Kakwani and Hyun (2022); Brockmeyer et al. (2021) and Papanikolaou (2021) shown below:

Kakwani and Hyun (2022) conducted research examining the degree of inequality in the Australian tax system. Their study reveals that tax discrimination occurs when various social groups face differing tax burdens, and they demonstrate that such discrimination results in diminished social well-being. In the research presented here, it was observed that fiscal inequality in the Mexican tax system poses a significant problem, as the system is deemed both inefficient and unfair. Consequently, this work undertakes an analysis of fiscal policy in Mexico.

When taxes exhibit regressive tendencies, inequality intensifies, as higher-income sectors end up paying a smaller proportion of their income in taxes compared to lower-income sectors. Therefore, this study delves into the analysis of low levels of tax collection and high levels of fiscal inequality in Mexico. Brockmeyer et al. (2021) explored the underutilized property tax in developing countries, modeling and estimating the welfare impacts of changes and applications of tax rates. Their model demonstrates how tax hikes impact welfare by reducing compliance, and suggests that enhancing enforcement raising tax rates can boost property tax revenues. Furthermore, they ascertain that taxpayers face liquidity constraints: consumption is only partially insured against temporary unforeseen income shocks, and an uptick in the tax rate prompts more taxpayers to opt for installment payments.

A striking parallel to our study is their examination of Mexico, where they likewise deduce that intensified law enforcement is not advantageous. In our research, our objective is to pinpoint the factors contributing to Mexico's diminished tax collection rates. The proposed methodology measures tax progressivity by assessing its elasticity to income variations. we propose measures tax progressivity by assessing its elasticity to income variations. Our findings reveal a positive degree of progressivity for the Income Tax and a negative degree for the Value Added Tax (VAT), indicating progressivity and regressivity, respectively. Papanikolaou (2021) examines tax progressivity and income inequality using personal income data from the Census Bureau's Current Population Survey (CPS) in the United States, spanning from 1996 to 2011. The researcher employs the Kakwani index to analyze tax progressivity for all personal salary income. The results reveal a tax system that exhibits partial progressivity but is predominantly regressive.

Similarly, our research focuses on analyzing of tax progressivity and regressivity. However, our primary focus is on tax collection, specifically identifying the variables that influence Mexico's tax revenue levels. We aim to discern the impact of tax progressivity on tax collection.

Previous studies have examined the tax system; however, the present research offers a more comprehensive analysis. It delves into the influence of the income tax progressivity and VAT rates on tax collection in Mexico. Subsequently, a time series econometric model is employed to identify the impact of income tax and VAT progressivity on tax collection using the Johansen cointegration methodology, along with the application of the error correction mechanism. These analyses have produced results that serve as valuable guidelines for formulating fiscal policies.

## 5. CONCLUSIONS

The present research had as its main axis of analysis tax collection, specifically; it sought to know the variables that cause the levels of tax revenue that Mexico manages, since the general objective was to know the influence that the progressivity of taxes represents in the tax collection.

Given that data on the independent variables—the level of progressivity of income tax and VAT—were unavailable, calculations were conducted to estimate progressivity as elasticity. This involved assessing the tax growth relative to a certain income.

Subsequently, a time series econometric model was developed, utilizing VAT and income tax collection as a percentage of GDP as the dependent variables, and the progressivity indices of income tax and VAT as the independent variables.

The econometric modeling began with ADF unit root tests for each variable, revealing unit root levels. However, after applying first differences, the variables became stationary, indicating an order of integration of I (1).

Continuing with the development of the VAR model, a test for determining the optimal number of lags was conducted, resulting in one being the optimal number. Consequently, the VAR model with a lag was constructed, followed by Johansen's cointegration test, which indicated that the variables cointegrate, establishing long-term equilibrium.

Further analysis of the cointegration equation revealed a positive relationship. Specifically, when income tax progressivity increases by 100%, income tax and VAT collection increase by 9.57%, and when VAT progressivity increases by 100%, collection increases by 39.47%. It's worth noting that these coefficients are significant, validating the model.

Regarding the VCE, it was observed that deviations between the short and long term are corrected by 83.58% within a year, which is statistically significant. Additionally, the model passed tests for normality, autocorrelation, and homoscedasticity, confirming the validity of the results.

This research presents findings that can strengthen tax policy in two key areas. Firstly, by increasing tax revenues, we enable enhanced public spending to improve citizens' quality of life. Secondly, by improving income distribution through a proposed redistribution of the tax burden the burden, will decrease among lower-income segments of the population and increase among higher-income segments.

In Mexico, insufficient economic resources hinder efforts to address existing gaps in the country. Greater government resources not only facilitate addressing these gaps and enhancing citizens' living conditions but also foster a positive reciprocal relationship between taxpayers and the state, forming a virtuous circle. This underscores the imperative to bolster tax collection in Mexico, including at the federal and state levels, with a focus on tax progressivity. Tax progressivity, alongside tax policy and income redistribution from higher-income to lower-income individuals, serves as economic tools to combat inequality. The study's limitations include a lack of more recent data. Future research recommendations involve conducting similar studies for corporate income taxes and, if

feasible, for major state and municipal taxes. This comprehensive analysis would provide insights into the collective effects of all taxes.

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