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Effect of economic growth and legal complexity on value-added tax

Efecto del crecimiento económico y de la complejidad legal sobre el impuesto al valor agregado

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Abstract

This work is aimed to determine the impact of economic growth and the legal complexity of the Value-Added Tax Act (LIVA, in Spanish) in the VAT collection between 1980 and 2016. This analysis is based on an ordinary least squares model transformed using the Box-Cox methodology. The results reveal a positive relation between economic growth and VAT collection, and a negative relation between the legal complexity index and VAT collection. It is suggested to extrapolate this analysis of the effects of legal reforms on the collection of other taxes, because a negative effect may be generated by the modifications made by increasing the complexity of tax laws and reducing the understanding of the tax payers. In consensus with the existing literature, a negative effect on the VAT collection is confirmed by the increase in the legal complexity index.

JEL Code: JEL: E62, C01, H30
Keywords: taxes; economic growth; legal complexity, VAT

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Resumen

El objetivo es determinar el impacto del crecimiento económico y de la complejidad legal de la Ley del Impuesto al Valor Agregado (LIVA), en la recaudación del IVA para el periodo 1980 - 2016. Para el estudio se utilizó un modelo de mínimos cuadrados ordinarios transformado mediante la metodología de Box – Cox. Los resultados muestran que existe una relación positiva entre el crecimiento económico y la recaudación del IVA y una relación negativa entre el índice de complejidad legal y la recaudación del IVA. Se recomienda extrapolar el análisis a otros impuestos para medir el impacto de sus reformas legales sobre su recaudación, se puede generar un efecto negativo por las modificaciones legales realizadas que podrían incrementar la complejidad de las leyes fiscales y reducir la comprensión de los sujetos obligados. En consenso con la literatura, se confirma un efecto negativo sobre la recaudación del IVA por el incremento en el índice de complejidad legal.

Código JEL: JEL: E62, C01, H30
Palabras clave: impuestos; crecimiento económico; complejidad legal; IVA

Introduction

Different economic and non-economic factors influence the decisions of taxpayers to comply or not with their tax obligations, including payment obligations. Income level, probabilities of being audited, tax audits, tax rate, tax benefits, fines, and penalties are economic factors. Non-economic factors are attitudes toward taxes, personal attitudes, trust in the tax authority and the use of resources, and established social and national norms (Barbuta, 2011).

As an economic factor with an impact on Value Added Tax (VAT) collection, this study considered Gross Domestic Product (GDP), a metric related to economic activity recognized by the United Nations, as the most appropriate indicator to measure economic growth. As a non-economic factor with influence on VAT collection, this study considered the legal complexity of the Value Added Tax Law (LVAT), understood as the ambiguity generated in the text of the LVAT by the different legal modifications and its consequent influence on the collection of the tax.

Using GDP as an indicator of economic activity is of analytical interest because, according to the 2018 System of National Accounts published by the United Nations and adopted by the National Institute of Statistics and Geography (Spanish: Instituto Nacional de Estadística y Geografía, INEGI, 2018), it is defined as "the value-added of all resident units plus taxes on products (minus subventions on products); i.e., gross value added to basic prices is the product valued at basic prices minus intermediate consumption valued at purchaser prices, plus taxes minus subventions on products."

Based on this definition, value-added should be related in a constant proportion to VAT, as long as the tax rate on products is unique and constant (Barro & Sala i Martin, 2009). However, the LVAT

throughout its history has established differentiated rates for various activities or sectors: 16% as a general rate, regardless of the act, activity, or geographical area within the national territory; currently 8% in the northern border region (previously 11%) regardless of the act or economic activity; 0% on food and medicines mainly, and an exemption for certain economic activities such as the agricultural sector. Therefore, not having a constant tax rate for all products distorts the theoretical postulate of proportionality, which is sufficient reason to analyze the relationship between GDP and VAT collection.

Using a legal complexity index as a non-economic factor can also be relevant because, according to Givati (2009), tax legislation is ambiguous in many cases. There are often different interpretations of the law, resulting in substantially different tax consequences. The inherent complexity of tax legislation and frequent changes in the law exacerbate this problem.

Givati (2009) defines complexity in a legal text as the uncertainty generated by the presence of ambiguity in the interpretations of the established provisions and classifies three aspects as sources of complexity in tax law: ambiguity concerning the precise meaning of the legal language, ambiguity concerning the application of the law to a specific situation, and ambiguity concerning the type of evidence sufficient to establish the necessary facts.

The presence of ambiguity generates legal uncertainty and creates problems for taxpayers. Frequent changes in the law exacerbate the generation of uncertainty and discourage some taxpayers from complying with their tax obligations by raising compliance costs.

The relevant argument for studying the relationship between the legal complexity of the LVAT and VAT collection is that the greater the legal modifications, the greater the ambiguity, and, therefore, the greater the complexity, which in turn increases compliance costs that harm negatively tax collection.

The motivation for carrying out this research is that VAT in Mexico is the second-most important source of revenue for the public treasury. Despite having been established in 1980, its earnings have not exceeded 4% as a proportion of GDP, although modifications have been made to lower the tax rate. This percentage is lower than the average for Latin American and the countries of the Organization for Economic Cooperation and Development (OECD), which exceed 6.5% and 6.9%, respectively (ITESM, 2013).

Therefore, studying the relationship and the impact of GDP as an economic factor and the legal complexity of the LVAT as a non-economic factor in VAT collection contributes to extending the results of previous studies that estimate the income elasticity of VAT collection as a function of GDP behavior (Cárdenas, Ventosa, and Gómez, 2008; CEFP, 2009; Sacasa, 2012). The expected results are a positive relationship between GDP and VAT collection and a negative relationship between the legal complexity of the LVAT and VAT collection. The following sections present the literature review, estimates, results, and conclusions.

Literature review

In the literature on growth, neoclassical and endogenous theories employ growth models that discuss the influence of taxes on economic growth. This analysis has been carried out from two different perspectives, studying the causes and the temporal relations between growth and taxes.

Exogenous forces in the neoclassical growth approach, such as technological progress and population dynamics, cause constant growth. Taxes can only temporarily influence the growth rate during successive transitions to growth with equilibrium (Karagianni, Pempetzoglu, & Saraidaris, 2013).

In endogenous growth models, the agents' behavior in the economy determines growth, while the diffusion of knowledge among producers and the positive externalities of human capital help avoid the tendency of diminishing returns on capital accumulation. Taxes affecting growth determinants such as returns on capital accumulation or the volume of investment in research and development have a permanent influence on economic growth (Barro & Sala i Martin, 2009).

There is an implied negative relationship between taxes and growth in both theories; however, this relationship has not been conclusively supported by empirical findings (Karagianni, Pempetzoglu, & Saraidaris, 2013).

Some studies address the relationship between taxes and growth and provide mixed evidence regarding these variables. Koester and Kormendi (1989), Levine and Renelt (1992), Easterly and Rebelo (1993), Slemrod and Yitzhaki (1995), Mendoza et al. (1997), and Kneller et al. (1999) concluded that there is a positive relationship and, in some cases, a weak correlation between the mean level of taxes and output in the short and long term.

King and Rebelo (1990), Barro (1991), Plosser (1992), Engen and Skinner (1992), Kormendi and Meguire (1995), Wright (1996), and Leibfritz et al. (1997) identified a negative correlation between taxes and economic growth.

De la Fuente (1997) analyzed the effects of fiscal policy on growth, specifically the impacts of the composition and level of government spending. He concluded that if total government spending as a proportion of GDP increases, growth decreases, while increased public investment boosts economic growth.

Mankiw (2016) states that there is a relationship between fiscal policy and economic growth because fiscal policy is an instrument to achieve an expansion or a reduction in economic activity. The transmission mechanism of fiscal policy to economic activity occurs through the use of instruments such as government purchases or taxes.

When the government decides to increase its spending (expansionary fiscal policy), it increases aggregate demand. Alternatively, the government can decrease taxes, implying an increase in

consumption and in aggregate demand. In the case of a contractionary fiscal policy, the government reduces its spending, which results in a decrease in aggregate demand. Alternatively, it increases taxes, resulting in decreased disposable income, reduced consumption, and a reduction in aggregate demand.

From the aggregate supply side, production depends on production factors, i.e., the amount of capital, the amount of labor, and the level of technology. It will be necessary to increase the amount of capital and improve the labor factor or the current technology to increase production levels in the long term. According to Solow (1956), to increase the amount of capital, it is neccesary to increase the rate of savings and investment in the economy, but at the same time, if the economy wants to increase the capital stock, it is necessary to reduce current consumption.

The economy must make better use of its economically active population by reducing the natural rate of unemployment to improve the use of the labor factor. However, policies that enhance labor efficiency, such as education or increased technological progress, lead to more productive use of capital and labor. Another way to improve the use of the labor factor would be the reduction of unemployment. However, this aspect may have high costs since, to reduce it, unemployment benefits should be reduced or wages lowered. However, these measures could harm people with lower incomes, and there is little consensus for them to be carried out (Mankiw, 2016).

On the aggregate supply or aggregate demand side, there are ways to increase production in the economy by using fiscal policy as an instrument to achieve an increase in GDP. This theoretical argument emphasizes the relationship between fiscal policy and economic growth through the use of instruments such as government spending and taxes, the latter of which have an impact on tax collection.

Previous research has shown that tax structures impact economic growth: Marsden (1983) showed that a change in fiscal policy would cause changes in the financial planning and decisions of a country, while Gober and Burns (1997) explained that national economies are greatly influenced by changes in the components of tax structures. Both concluded that fiscal policy structure and decisions influence economic activity.

Despite the existing relationship between fiscal policy and economic growth generated through the use of the fiscal instrument known as the tax rate, it has been demonstrated that modifying rates—particularly in times of recession—could cause unfavorable changes in both economic growth and tax collection levels. The Laffer curve illustrates the relationship between the tax rate and the amount of tax collected and establishes that a higher tax rate does not always generate higher tax collection. That is to say, there is a threshold at which the relationship that establishes that the higher the tax rate, the higher the tax collection breaks down (Parkin & Loria, 2015).

Hinrichs (1966) and Musgrave (1969) studied the relationship between the proportion of tax revenues and GDP, concluding that this relationship is non-existent in developing countries.

From the literature review, it is possible to conclude a positive or negative relationship between fiscal policy and economic growth when seeking to expand or contract production. Expansion or contraction have effects on tax collection, a relationship that is part of the study objective of this research when trying to explain the effects of economic growth on Value Added Tax collection.

The literature suggests that tax collection is conditioned by various factors, including structural elements such as per capita income, the share of agriculture in GDP, and the level of trade openness, as well as by other factors such as corruption, political stability, and the proportion of direct and indirect taxes, among others (Gupta, 2007).

The Economic Commission for Latin America and the Caribbean (Spanish: Comisión Económica para América Latina y el Caribe, ECLAC, 2009), an agency of the United Nations, identifies five direct determinants of tax collection: tax legislation, the value of the taxable material, the rules of payment and income of taxes, and non-compliance in the payment of tax obligations, among other factors.

This organization also identifies as second-degree determinants the objectives of economic and fiscal policy, the preferences of tax policymakers, economic variables, and the evaluation of the costs and benefits of tax evasion practices (ECLAC, 2009).

The European Commission concludes that VAT regulation (tax level, differentiated rates, exceptions, etc.) conditions its collection. However, the same is true of other macroeconomic factors (GDP growth, consumption level, imports, exports, among others) (Bikas & Andruskaite, 2013).

In line with Bikas and Andruskaite (2013), and according to Barro and Sala i Martin (2009), the relationship of GDP and tax collection, from the point of view of growth accounting, is established when there is a production or sales tax. Subsequently, competitive companies will comply with the condition that the marginal productivity of labor and the marginal productivity of capital will be equal to factor payments divided by $(1-\tau)$, i.e.:

$$F_L = \frac{w}{1-\tau};\ F_K = \frac{R}{1-\tau}$$

Where F_L is the marginal productivity of labor and F_K is the marginal productivity of capital, w is the wage, R is capital gains, and τ is the marginal tax rate on production. Therefore, if the tax on production (or sales) is proportional and the mean and marginal tax rates are identical, the tax collection will be equal to a constant proportion of production determined by (τY).

Production Y will be equal to the payment of the factors plus what is collected by the indirect tax; then the production will be $Y = Rk + wL + \tau Y$. This applies when the proportional value-added tax is applied equally to the labor factor and the capital factor, i.e.: $\tau_K = \tau_L$. Then if τ_K and τ_L are different, the weights on K and L will also be different, and the proportion (τY) will no longer be constant (Barro & Sala i Martin, 2009).

As mentioned in previous paragraphs, according to the System of National Accounts Base 2013, the Gross Value Added of the economy is defined as "the value-added of all resident units plus taxes on products (minus subventions on products)." In other words, the gross value added at basic prices is the production value at basic prices minus intermediate consumption valued at purchaser prices, plus taxes minus subventions on products. According to Barro and Sala i Martin (2009), and based on this definition, the value-added should be related in a constant proportion to VAT. However, as there are differentiated rates, zero rates, and exemptions, the theoretical concept established by Barro and Sala i Martin (2009) and the System of National Accounts Base 2003 is not fulfilled. The distortions generated by the current VAT tax structure are a valid argument to analyze the relationship and impact of economic growth on VAT collection.

The relationship between economic growth and VAT collection in the case of Mexico has been studied by Cárdenas, Ventosa, and Gómez (2008). The study was carried out with data from the first quarter of 1980 to the second quarter of 2005. The figures were expressed in constant pesos from 2005, in a cointegration model with integration I(1) in levels (non-stationary series) and I(0) in first differences (stationary series). The order of integration was determined by applying the Dicky-Fuller GLS test to the seasonally adjusted series (Census X12-ARIMA). They concluded with a confidence level of 5% that there is insufficient evidence to reject the existence of a unit root and with the same percentage of confidence rejected the null hypothesis of a unit root for all series in first differences. The elasticity was estimated using a model where VAT (dependent variable) is the logarithm of revenue in period (t), and income is the logarithm of GDP in period (t), with dichotomous control variables representing the 1983 and 1992 legislative changes in the tax rate as proxy variables for structural change. The results demonstrated that the long-term income elasticity of VAT revenue relative to GDP is 1.12, which means that, given a one percentage point increase in GDP, long-term VAT revenue increases by 1.12%.

The Center for Public Finance Studies (Spanish: Centro de Estudios de las Finanzas Públicas, CEFP, (2009) estimated the income elasticity of VAT collection relative to GDP using data from the first quarter of 1980 to the second quarter of 2009—figures expressed in constant pesos from 2003—to determine the impact of VAT on the planning and formulation of the public budget, the monitoring of tax collection, and the estimation of the public deficit. Following the work of Cárdenas, Ventosa, and Gómez (2008), the data were expressed in logarithms and were seasonally adjusted (X-11 ARIMA). The order of integration was determined using the Augmented Dickey-Fuller (ADF) test to identify the existence of a unit root in the series, both in level and in their first differences. The results were that the series are non-stationary in level and stationary of order one in their first differences. The control variables incorporated in the model are the same as those used by Cárdenas, Ventosa, and Gómez (2008). The results of the estimations lead to the conclusion that, with an increase of one percentage point in GDP, VAT collection

increases in the long term by 1.88%. The CEFP (2009) explains that the differences in the results from the work of Cárdenas, Ventosa, and Gómez (2008) are mainly explained by the difference in the analysis periods since the control variables in both works followed the same methodology. It further mentions that in Cárdenas, Ventosa, and Gómez (2008), it is recognized that the income elasticity of VAT relative to GDP is relatively low.

The United Nations Development Program (Sacasa, 2012) also studied the relationship between VAT and GDP for the period from the third quarter of 1981 to the fourth quarter of 2009, with figures expressed in constant pesos from 2003, with a model in which VAT collection is considered a function of income level, measured through GDP. The elasticity estimation was performed using the Johansen procedure (1988) to obtain a cointegration vector, considering the presence of non-stationary series. Through the Engle and Granger (1987) theorem, this cointegration vector was considered an error correction mechanism. Therefore, since GDP and VAT collection are non-stationary series I(1), a cointegration model was specified using the Johansen (1988) procedure for its estimation. By normalizing the cointegration vector, it was concluded that there is a stable long-term relationship between VAT collection and GDP. The results concluded that "with a one percentage point increase in GDP, long-term VAT collection increases by 1.28% (Sacasa, 2012).

The works of Cárdenas, Ventosa, and Gómez (2008), the Center of Public Finance Studies (Spanish: Centro de Estudios de las Finanzas Públicas, CEFP, 2009), and the PNUD (Sacasa, 2012) lead to the conclusion that it is feasible to estimate the income elasticity between economic growth and Value Added Tax (VAT) collection. The three studies identified in the literature followed the cointegration methodology. Their results facilitate the conclusion that the relationship between both variables is positive and that movements in GDP generate movements in tax collection.

Table 1
Main characteristics of the studies analyzing the relationship between GDP and VAT collection

Concept	Cárdenas, Ventosa, and Gómez (2008)	CEFP (2009)	PNUD (2012)
Elasticity	1.12	1.88	1.28
R^2	0.93	0.96	nd
Study period	1T1980-2T2005	1T1980-2T2009	3T1981-4T2009
Data	Constant pesos from 2005	Constant pesos from 2003	Constant pesos from 2003
Estimation method	Cointegration	Cointegration	Cointegration
Tests	Augmented Dickey-Fuller (Elliot, Rothenberg, and Stock, 1996)	Augmented Dickey-Fuller (Elliot, Rothenberg, and Stock, 1996)	Johansen (1988)

Source: Cárdenas, Ventosa, and Gómez (2008), CEFP (2009), and Sacasa (2012)

Table 1 presents the main characteristics of the three studies that analyze the relationship between GDP and VAT collection.

In addition to the conditioning factor exerted by economic growth on tax collection, other factors influence taxpayer compliance with tax obligations and can generate positive or negative effects on tax collection due to their influence on taxpayer behavior and decisions (OECD, 2004).

The ECLAC (2009), Gupta (2007), Barbuta (2011), and Helhel and Ahmed (2014) have established some classifications of the factors that condition tax collection. These classifications establish that the factors can be of an economic and non-economic nature or also of an internal and external nature.

Barbuta (2011) classified the factors as economic and non-economic. Among the economic factors, as mentioned in previous paragraphs, she highlights the level of income, tax rates, tax benefits established in the tax structure, the probability of being audited, and fines or penalties for failure to pay taxes (partially or totally).

The non-economic factors that influence tax compliance are taxpayer perception of taxes; personal, social, and national norms; and perceptions of the fairness of the tax system relating to distributive justice.

Helhel and Ahmed (2014) classified the factors that impact tax compliance into two groups, internal and external. The internal determinants are the way taxpayers think and their perception of taxes. In contrast, the external determinants are the tax system, the activity of the tax authorities regarding taxpayers, and the legal provisions.

These classifications are important because they broaden the universe of factors that can influence VAT collection, in addition to income. Based on these classifications, this research seeks to expand the study of the factors that impact VAT collection and considers, in addition to GDP, the influence exerted by the legal complexity of the VAT law through the legal complexity index created in the work of Moreno, Beltrán, and Mata (2007), such that the impact of GDP and legal complexity on VAT collection is analyzed jointly.

The study of legal complexity is a relatively new topic if contrasted with the studies of economic aspects that have their origin in the Wealth of Nations by Adam Smith in 1776. The first antecedents of the analysis of legal complexity are recorded from work carried out in 1972 by the American Bar Association (ABA), which consisted of analyzing the legal text of the Tax Code of the United States of America.

From the work of the American Bar Association and until the first decade of the 21st century, the topic of legal complexity and text mining techniques emerged as a practice for measuring the evolution of different legal texts, with research in the tax area being the most relevant due to its implications in the relationship between the State and taxpayers (ABA, 2018).

Diver (1983), in his studies on the optimal precision of administrative rules, concluded that a text is complex when it presents a low level in three elements: transparency, accessibility, and consistency; therefore, according to this author, a law is more complex when these three elements are less present.

Schuck (1992), one of the first authors to address the issue of legal complexity, defined a system as complex "when its rules, processes, and institutions present four characteristics: density, technicalities, differentiation, and uncertainty," and highlighted that even though his research was one of the first works on legal complexity, the tax law was already identified as a law with a high degree of complexity, due to the presence of these four elements.

Kades (1997) stated that the best example of legal complexity is found in tax law. Although he was referring to the Federal Tax Revenue Act of the United States, this statement is useful to demonstrate the existence of complexity in tax laws. The first definition he used regarding complexity was the intention of societies to regulate all human interactions, an intention that instead of simplifying complicates the legal texts that regulate human relations. He followed up on Diver (1983), taking up his arguments that a legal text is more complex when it contains less transparency, is not very accessible, and shows little consistency or greater ambiguity.

Surrey (1969), the author of several studies on the U.S. tax system, indicated that "complexity results from the fact that complicated tax laws are applicable in a very complex economic and legal system; society naturally creates and demands a complex legal system." His argument is along the same lines as Diver (1983) and Kades (1997), in that by seeking to regulate every human interaction, rules become complex texts.

Katz and Bommarito (2014), authors recognized for their contributions to the measurement of legal complexity, in their first research generated an indicator based on the number of pages in a text, without going beyond simple word count. As a result, there were no indicators to determine whether a regulation or any other text with legal effects was more or less complex based on modifications made.

To address the need to measure legal complexity in a text, Katz and Bommarito (2014) developed an indicator that integrates three components: the structure, language, and interdependence of a legal text.

To measure the structure of a law, the authors considered that the text of a legal document has a structure similar to a hierarchical network or tree structure. The depth of each element represents the branches of the tree down to the smallest detail, culminating in a decision tree diagram.

The authors proposed that to measure the concept of language, the texts of this tree, which go from the general to the particular, in the structure of a law, are represented by words, which comprise the language and can have different lengths and meanings.

In order to measure the interdependence of a law, they considered the references contained in the text of a law to other texts within the same law or to other texts of different laws, so that to achieve an understanding of a legal text, it would be necessary to simultaneously review or understand legal texts within the text of the first law or even other additional laws to which reference is made.

Ruhl and Katz (2015) published research in which they measured the legal complexity of the U.S. tax system. The authors concluded that a legal system is more complex when there is a higher degree of interdependence among its components. In other words, in a simple legal system, modifying or eliminating any element would not greatly alter the functioning of such a system because there is a low interrelation between the texts of the different laws. This is not the case in complex systems, in which, when any ordinance is modified, all the texts related to this modification have to be adjusted.

In Mexico, the Center for Economic Studies of the Private Sector (Spanish: Centro de Estudios del Sector Privado, CEESP, 2018), an agency belonging to the Business Coordinating Council, indicated that the country has a complex tax system that is costly to manage, which encourages tax evasion and avoidance due to the multiplicity of taxes, exemptions, differentiated rates, and special taxes.

The Attorney General for Taxpayer Defense (Spanish: Procuraduría de la Defensa del Contribuyente, Prodecon) explains that taxpayers in Mexico face difficulties in complying with the obligations established by law due to the excessive and complex regulations that hinder the determination of contributions, implying high costs and contributing a discouraging factor in compliance (Bernal, Padilla, & Pérez, 2011).

The literature review detected a relationship between VAT collection and some economic and non-economic factors, such as economic growth and the legal complexity of the VAT law. In the case of GDP and VAT collection, the working hypothesis is that there will be higher VAT collection in periods of higher economic growth. In the case of VAT collection and the legal complexity of the VAT law, the expected results are that in periods of higher legal complexity, there will be less VAT collection.

The motivation for studying these relationships is that VAT represents the second-largest revenue source for the Public Treasury. Since it entered into force in 1980, its collection has not exceeded 4% as a proportion of GDP, despite variations in the tax rate.

For the study of these relationships, the methodology and results of the tests that allow for the measurement of the impact of GDP and the legal complexity of the VAT law on VAT collection are presented below.

Methodology

The estimation carried out in this research took as a basis the work of Cárdenas, Ventosa, and Gómez (2008) and Katz and Bommarito (2014). The former was used to estimate the elasticity of the relationship between VAT collection and economic growth, and the latter was used to estimate the elasticity of the relationship between VAT collection and the legal complexity of the VAT law.

The model used was transformed using the Box-Cox method, firstly to find an alternative method to the work done on the relationship between these two variables, and secondly for the following technical reasons: it allows for the correcting of problems of heteroscedasticity, non-normality, and non-stationarity without resorting to error correction models, ARIMA (p,q), or others, where the interpretation of the marginal effect is not direct (Porunov, 2010). As control variables, proxy variables were incorporated whose basis is the legislative change that modifies the VAT tax rate and are in accordance with the work of Cárdenas, Ventosa, and Gómez (2008) as variables that simulate structural change during the life of the tax and that have affected its collection.

This research contributes to the work done on the economic determinants affecting VAT collection by integrating the legal complexity indicator estimated by Moreno, Beltrán, and Mata (2017) into the model as an explanatory variable. This legal complexity indicator was based on the work done by Katz and Bommarito (2014).

The indicator of the legal complexity of the LVAT, proposed in this research, considers the structure of the law as how the legal text is organized and from which it is possible to define the depth of the elements that form it. In other words, a higher numerical weighting is assigned as the depth of each element of the Law increases; the values range from one to five depending on whether it is an article, paragraph, fraction, clause, or numeral, respectively, such that it is possible to identify the moments in which additions or repeals have been made to the text of the VAT law.

Unlike the model proposed by Katz and Bommarito (2014), the language component was analyzed from the perspective of entropy (S) to determine how many times each word is repeated in the text as an indicator of relative frequency. Text mining techniques were used on each of the published texts of the VAT law from 1978 to 2016 to estimate relative frequency. The entropy estimation demonstrates that when a text is uniform, its entropy is zero, and when this value is close to one, it is a non-uniform text.

The interdependence component was also adjusted as stipulated by Katz and Bommarito (2014). It was analyzed considering the internal and external references in the text of the law, i.e., four types of references were considered: when referring to a previous paragraph; to some element within the VAT law; to some specific element of another law; and some general reference to another law. The weights to

calculate interdependence were assigned under the assumption that it is easier to understand a reference to the previous paragraph than when citing some generic text of another law other than the VAT law. Therefore, the values of the weights range from one to four, with number one assigned to the simplest reference, which is to the previous paragraph, and so on.

The joint legal complexity indicator was determined by adding the values obtained for every component (structure, language, and interdependence) to obtain a value for each quarter of the period from 1980 to 2016. The model proposed in this research incorporated this value to calculate the elasticity of VAT collection relative to the legal complexity of the VAT law.

Annualized quarterly figures at constant prices from 2013 prices, seasonally adjusted (X-13 ARIMA) for the period from 1980 to 2016 on VAT and GDP, were used to carry out this estimate. For the legal complexity indicator, the estimation made by Moreno, Beltrán, and Mata (2017) was used, which combines in a quarterly indicator the values of structure, language, and interdependence.

It is worth mentioning that the legal complexity indicator used in the estimation of VAT collection has advantages and limitations. First, it considers different weightings to incorporate the evolution of the LVAT text in three complexity indicators, according to the methodology (Katz & Bommarito, 2014), which has not been found so far in the literature for the case of Mexico. A limitation is the time required to collect the universe of published legal texts to be compared, in addition to the computational effort needed for the application of text mining.

Based on these definitions and the figures used, the model is a multiple regression specification with a natural logarithm in the dependent and independent variables. Thus, the estimated coefficients can be interpreted as an elasticity between the variables (Gujarati & Porter, 2010):

$$\ln(\mathrm{VAT}_t) = \alpha_0 + \alpha_1 \ln(\mathrm{GDP}_t) + \alpha_2 \ln(\mathrm{C}_t) + \mathrm{u}_t \quad (1)$$

Where:

VAT_t = VAT collection, at constant prices from 2013 (millions of pesos)

GDP_t = GDP at constant prices from 2013 (millions of pesos)

C_t = Legal complexity index

u_t = Random disturbance

The original model (Equation 1) is difficult to estimate since the economic series of VAT and GDP are non-stationary series and present positive correlation (Cárdenas, Ventosa, & Gómez, 2008), which violates the basic assumptions of the ordinary least squares model, implies a spurious regression, and thus yields inconsistent estimators (Greene, 2018).

It is possible to use the Box and Cox transformation on the natural logarithm of VAT collection to correct for these problems and ensure meeting the assumptions of the ordinary least squares model. This procedure makes it possible to transform the dependent variable of a regression model such that the residuals behave normally, with zero mean and constant variance (Porunov, 2010).

The Box and Cox method modifies the dependent variable $\ln(\mathrm{VAT_t})$ of the regression model by optimally choosing a parameter θ such that Equation 2 satisfies that $v_t \sim N(0, \sigma^2)$, which corrects the problem of heteroscedasticity, non-normality, and non-stationarity (Vélez, Correa, and Marmolejo-Ramos, 2015).

$$[\ln(\mathrm{VAT_t})]^{\theta} = \beta_0 + \beta_1 \ln(\mathrm{GDP_t}) + \beta_2 \ln(\mathrm{C_t}) + v_t \quad (2)$$

In Equation 2, the variable $[\ln(\mathrm{VAT})]^{\theta}$ is the transformation of the natural logarithm of VAT collection under parameter θ, at constant prices.

On the other hand, it is important to note that the family of transformations proposed by Box and Cox (1964) for a dependent variable $y(\theta)$ is:

$$y(\theta) = \begin{cases} \dfrac{(y+m)^{\theta} - 1}{\theta}; & \theta \neq 0 \\ \ln(y+m): & \theta = 0 \end{cases}$$

$$m = 0 \text{ if } y > 0$$

Where the maximum likelihood function for the regression $y(\theta) = X\beta + u$ is:

$$f(y) = \frac{1}{(\sqrt{2\pi\sigma^2}} e^{-\frac{(y(\theta)-X\beta)'(y(\theta)-X\beta)}{2\sigma^2}} J(\theta, y)$$

Moreover, the Jacobian $J(\theta, y)$ is given by:

$$J(\theta, y) = \prod_{i=1}^{n} \frac{\partial y_i(\theta)}{\partial y_i} = \prod_{i=1}^{n} y_i(\theta - 1)$$

The maximum likelihood estimators of β and σ^2 are obtained under this approach, which are given by:

$$\hat{\beta}(\theta) = (X'X)^{-1} XY(\theta)$$
$$\hat{\sigma}^2(\theta) = Y(\theta)(I - P)Y(\theta)/n$$

The optimal value of θ is simultaneously obtained under maximum likelihood (Vélez, Correa, and Marmolejo-Ramos, 2015).

Dichotomous control variables d_k can be added to delimit and incorporate k structural changes in VAT law over the years 1980-2016 to estimate the model proposed in Equation 2, similar to what was done in Cárdenas, Ventosa, and Gómez (2008).

In that case, the resulting equation would be:

$$[\ln(VAT_t)]^{\theta} = \beta_0 + \beta_1 \ln(GDP_t) + \beta_2 \ln(C_t) + \sum_{k=1}^{m} \varphi_k d_k + v_t \quad (3)$$

In Equation 3, it is possible to have autocorrelation problems due to the temporary nature of the variables, hence the need to use the iterative Prais-Winsten and Cochrane-Orcutt procedure to solve such issues and obtain robust marginal effects between the independent variables and the dependent variable (Kristoufek, Janda, & Zilberman, 2014).

Specifically, the Prais-Winsten and Cochrane-Orcutt procedure iteratively re-estimates a regression model in the framework of an AR(p) specification for the random term v_t, which is given by $v_t = \phi_1 v_{t-1} + \phi_2 v_{t-2} + \cdots + \phi_p v_{t-p}$ for some $p \geq 1$. The procedure begins with an initial point $\widehat{\phi}_i$ for coefficients i = 1,2,…,p and where convergence is expected to be reached (Greene, 2018).

In the case of Equation 3, the transformed model would be:

$$Y_t^* = Y_t - \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \cdots + \phi_p Y_{t-p}$$
$$X_{j,t}^* = X_{j,t} - \phi_1 X_{j,t-1} + \phi_2 X_{j,t-2} + \cdots + \phi_p X_{j,t-p}$$

Where Y_t^* is the dependent variable and $X_{j,t}^*$ are the explanatory variables to obtain the auxiliary equation:

$$\{[\ln(VAT_t)]^{\theta}\}^* = \beta_0 + \beta_1 \{\ln(GDP_t)\}^* + \beta_2 \{\ln(C_t)\}^* + \sum_{k=1}^{m} \varphi_k d_k^* + \varepsilon_t \quad (3.1)$$

Where ε_t is a white noise process. In this regard, Breusch-Pagan and Ljung-Box hypothesis tests are used to corroborate the autocorrelation correction and determine the order for the AR(p) model.

It is important to note that the above methodology is an alternative procedure to cointegration or other techniques used by various authors. Specifically, Sakia (1992) studied the transformation proposed by Box and Cox (1964) and suggested that to perform the data analysis, a new model must be

generated from the original data, containing the main characteristics of the phenomenon to be studied by performing a transformation on the data, so as to meet the assumptions of independence, normality, and constant variance. He concludes that the Box and Cox transformation—besides being widely used since the authors proposed it in 1964—has been widely used in determining functional relationships in economics.

Castaño (2011) started from the fact that classical linear regression analysis in econometric models is based on the behavior of errors in an additive way, with normal distribution and constant variance. However, these assumptions are not met when there are outliers in the data. He concludes that the Box and Cox procedure is sensitive when there are outliers in the dependent variable. Therefore, when there are no outliers, the Box and Cox procedure is efficient, even in small samples.

Porunov (2010) proves that the Box-Cox transformation is an alternative to traditional techniques, such as generalized least squares, Box-Jenkins methodology, or error correction (cointegration) models, to deal with the violation of the classical regression model assumptions of non-normality, heteroscedasticity, or non-stationarity.

This research follows this alternative approach since, in the literature, there is research with the VAT and GDP variables, e.g., Cárdenas, Ventosa, and Gómez (2008), that uses the usual methods. In other words, the spirit of this research is to extend its results to have a comparative framework regarding the inclusion of the complexity variable.

Estimations and results

This section presents the estimations and results of the transformed model (Equation 3.1) according to the methodology described in the previous section. To this end, it is necessary first to verify that the time series are not stationary in levels, stationary in first difference and that the residuals of Equation 1 do not fulfill the assumption of normality, homoscedasticity, and absence of autocorrelation. Therefore, the Box-Cox transformation is a relevant tool in conjunction with the Cochrane-Orcutt procedure.

Table 2a demonstrates that the time series of the specified model are not stationary in levels but are stationary in first differences, as reported in Cárdenas, Ventosa, and Gómez (2008), CEFP (2009), and Sacasa (2012).

Table 2a
Violation of regression model assumptions in Equation 1

Test	Variables in levels		
	$\ln(VAT_t)$	$\ln(GDP_t)$	$\ln(C_t)$
DFA	0.170 (0.9420)	1.746 (0.9982)	1.310 (0.6248)
PP	0.695 (0.9876)	3.245 (1.000)	1.691 (0.6247)
KPSS	3.30 (0.000)	1.44 (0.000)	1.50 (0.000)
Test	Variables in first difference		
	$\ln(VAT_t)$	$\ln(GDP_t)$	$\ln(C_t)$
DFA	19.498 (0.000)	17.265 (0.000)	12.514 (0.000)
PP	21.075 (0.000)	16.144 (0.000)	12.512 (0.000)
KPSS	0.013 (0.1234)	0.042 (0.1576)	0.014 (0.1618)

Source: created by the author

Table 2b demonstrates that the residuals of regression Equation 1 present heteroscedasticity, normality, and serial correlation problems since the null hypothesis is rejected in each case. However, there are no multicollinearity problems since the VIF statistic is less than ten.

Table 2b
Violation of regression model assumptions in Equation 1

Test	Test statistic	p value
White	48.315	0.000
Breusch-Godfrey (1-3 lags)	49.866	0.000
Jarque-Bera	20.213	0.000
VIF	1.96	NA

Source: created by the author

Given the results in Table 2b, the Box-Cox transformation was carried out, which required calculating the parameter θ to normalize the residuals of Equation 1, thus allowing for the correction of the problems described for the original ordinary least squares model.

Table 3 presents the estimation of parameter θ corresponding to the transformation of the dependent variable $ln(\text{VAT})$. The estimator of θ is significant at a confidence level above 95%.

Table 3
Estimation of the parameter θ for the Box-Cox transformation

ln(VAT)	Coefficient	Standard Error	z statistic	p value	Confidence interval (95%)	
θ	3.6215	0.1244	29.12	0	3.3778	3.8653

Source: created by the author

Subsequently, from the estimation of parameter θ, the regression model was estimated with the Box-Cox transformation through maximum likelihood to find robust estimators and satisfy the condition

that the random disturbance is $N(0, \sigma^2)$. However, given the serial correlation problems, the Cochrane-Orcutt procedure was also applied to estimate the model of Equation 3.1.

Table 4 presents the marginal effects for the Box-Cox model, in conjunction with the Cochrane-Orcutt procedure, demonstrating that the greater the legal complexity, the lower the VAT collection. The negative coefficient (-1.139) can be interpreted as a long-term elasticity between the variables. Likewise, the positive coefficient (4.510) positively relates VAT to the GDP variable and can be studied similarly as an elasticity. The signs correspond to the theoretical framework reviewed and are in line with expectations (Katz and Bommarito, 2014; Cárdenas, Ventosa, and Gómez, 2008).

Table 4
Estimation of model parameters

ln(VAT)	Marginal effect	Standard error	t statistic	p value
ln(C)	-1.139	0.487	-2.339	0.010
ln(GDP)	4.510	0.661	6.825	0.000
Unit root test on residuals				
t statistic	-2.345			
p value	0.0932			
Heteroscedasticity test (White)				
Chi2 statistic	2.73			
p value	0.1183			
Serial correlation test (Breusch-Godfrey, 4 lags)				
Chi2 statistic	1.673			
p value	0.1959			
Serial correlation test (Ljung-Box, 4 lags)				
Chi2 statistic	0.2948			
p value	0.5872			
Jarque-Bera test				
Chi2 statistic	2.742			
p value	0.2538			

Source: created by the author

Concerning the behavior of the residuals, Table 4 also demonstrates that they constitute a stationary time series, and there are no problems of heteroscedasticity or serial correlation since the p-value is greater than 5%. Likewise, the normality assumption is met according to the Jarque-Bera test.

Similarly, Table 5 presents the estimation of the parameters of the dichotomous variables and control variables, which indicate structural changes in the period from 1980 to 2016 and which are given by the change in the VAT tax rate in the years they were carried out. As can be seen, the change in the tax

rate has positive or negative effects on VAT collection, depending on whether the change in the rate increases or decreases.

Regarding eliminating the control variable d1995 due to its non-statistical significance, it was determined not to eliminate it for the following reason. Economically, it is relevant to keep it within the estimation because in 1995 there was the largest drop in GDP since the 1930s. Although the tax rate was increased from 10% to 15% to strengthen public finances, the effects on VAT collection that year were not significant since it reached a figure of 2.2.% as a proportion of GDP, a figure similar to that recorded in 1994 with a 10% tax rate. This behavior may justify the lack of statistical significance of this control variable.

Table 5
Estimation of the parameters of the control variables

ln(VAT)	Coefficient	Standard error	t statistic	p value
d1983	5.459	0.20	27.83	0.000
d1992	-0.681	0.14	-4.91	0.000
d1995	-0.226	0.15	-1.51	0.132
d2010	1.112	0.14	8.06	0.000

Source: created by the author

Conclusions

Public finances and tax collection are of great relevance due to the relationship between the State and taxpayers through the imposition of contributions. To date, there has been a history of research related to the behavior of the economy and tax revenues, specifically regarding the Gross Domestic Product and Value Added Tax. The most relevant study is called "Income elasticity of federal taxes in Mexico. Effects on federal tax collection," written by Cárdenas, Ventosa, and Gómez (2008). They concluded that the income elasticity of VAT collection relative to GDP is 1.12, which means that with a 1% increase in GDP, VAT collection will grow by 1.12%.

This work determined that the higher the economic growth, the higher the Value Added Tax collection. This result would seem obvious given that GDP is the value-added of the economy, and if it increases, it should necessarily generate more revenue. The theoretical postulate of growth accounting establishes that if the sales tax were homogenous for all final products, this relationship would be constant, meaning that every time the value-added of the economy increases, VAT collection would also increase. However, in Mexico, due to differentiated rates and exemptions, the value-added tax is not homogeneous, and, consequently, some distortions make the relationship not constant. Therefore, a situation may arise

in which growing economic sectors are not taxed with VAT. This situation, although unlikely, is possible and, if it were to occur, collection would not increase.

The results obtained in this research are consistent with the estimates made in previous works regarding the direct relationship between GDP and VAT collection, i.e., it is confirmed that the higher the economic growth, the higher the VAT collection. However, the results obtained differ in terms of magnitude relative to previous research since the elasticity calculated is 4.510, when in previous studies, the elasticity ranges between 1.12 and 1.88. It is important to consider that the study periods differ, which may be why the elasticities are different.

From the perspective of non-economic factors that influence tax collection, there is the issue of tax legislation, and this research following the model developed by Katz and Bommarito (2014), made estimates regarding the impact of legal complexity on VAT collection.

The results show that VAT collection and legal complexity (structure, language, and interdependence) have an inverse relationship. An inverse relationship means making legal modifications to express in detail the different interactions between the tax authority and the taxpayer can cause, in terms of understanding by the obligated parties, a counterproductive effect to the objectives originally outlined in the modifications made, with a consequent deterioration of public finances.

The estimation of the impact of legal complexity on VAT collection is in line with the different theorists who have investigated the issue of complexity in a legal text, specifically those who analyzed the tax laws of the United States. That is to say, the greater the complexity, the greater the effort required to analyze and understand the legal texts, to the extent of requiring the support of an expert in tax matters, with the consequent increase in costs that impacts compliance with obligations, including payment obligations.

The contribution of this research is to demonstrate that, in addition to the effects of economic growth on VAT collection, the legal complexity generated by the modifications to the text of the law has a negative impact on tax collection, i.e., there is an inverse relationship between both variables. The estimated elasticity for these variables was negative (-1.139), which means that with a one-unit increase in the legal complexity indicator, collection will decrease by 1.139%.

Additionally, this research helped identify the feasibility of extrapolating the use of robust statistical tools and text mining to calculate the legal complexity of any other law different from the VAT law, hence reducing the discretionality in the modifications proposed to the Mexican Congress in order to mitigate the possible negative effects generated by such modifications.

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