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Dynamic effect of legal complexity on the value added tax in Mexico

Javier Moreno
Universidad Panamericana

Leovardo Mata
Universidad Anáhuac México

Jaime Humberto Beltrán
Universidad Anáhuac México; Instituto Tecnológico Superior de Tantoyuca

Griselda Dávila
Universidad Panamericana

Abstract

This paper studies legal complexity and its dynamic relationship with the Value Added Tax Law, from its original version published in 1978 to the current version. To this end, the variables structure, entropy, and interdependence of the legal texts associated with the VAT Law constitute the complexity index. A VAR model then finds evidence of Granger causality between legal complexity and VAT, although no cointegration relationship exists. Furthermore, an inverse relationship between the variables is confirmed, quantifying the short-term effect of legal complexity and comparing it for robustness with the estimation of an ARIMAX and generalized OLS model.

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Contact: Javier Moreno - jmorenoe@up.edu.mx, Leovardo Mata - leovardo.mata@anahuac.mx, Jaime Humberto Beltrán - jaime.beltrang@anahuac.mx, Griselda Dávila - gdavila@up.edu.mx.
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1.- Introduction

Legal regulations can be complex, meaning they can be ambiguous or unclear. This paper uses the method developed by Katz and Bommarito (2014) to analyze this complexity in Mexico's Value Added Tax Law (LIVA), from its original version in 1978 to the reforms it underwent in 2021. Using their methodology, an indicator called the "complexity index" is created. This index reflects the evolution of the legal complexity of the LIVA over time.

Since its formal implementation in 1980, VAT collection has increased steadily each year. However, this growth has not exceeded 4% of Gross Domestic Product (GDP), reaching a peak of 3.85% in 2010. In this sense, public finances need to identify factors beyond economic growth that can improve the efficiency of VAT collection, such as the legal complexity variable presented in this paper.

The hypothesis proposed in this research states that greater complexity in the law regulating the value-added tax (VAT) harms VAT collection levels. In other words, an inverse relationship is expected between the variable known as legal complexity and VAT collection.

In this regard, Givati (2009) defines the complexity of a legal text as the uncertainty generated by ambiguity in the interpretation of established provisions. One aspect that characterizes this ambiguity is the legal language used in relation to the precise meaning of legal terms and the relative frequency with which they appear in legal texts. In this sense, the complexity index seeks to capture this pattern of behavior in legal texts.

Intuitively, a variable closely linked to VAT revenue is Gross Domestic Product (GDP). VAT is a tax levied on the consumption of goods and services, while GDP represents the total value of production. Since a significant portion of GDP is allocated to domestic consumption, the VAT tax base is inherently linked to overall economic activity. Therefore, an increase in GDP is expected to translate into an increase in consumption and, consequently, VAT revenue.

In Mexico, tax amnesties have had a positive impact on Value Added Tax (VAT) collection, as they modify tax compliance incentives. In the short term, these programs typically result in a temporary increase in revenue, as they allow taxpayers to regularize VAT debts with reductions in fines and surcharges. However, in the medium and long term, the recurrence of amnesties is expected to have no or even a negative effect.

Similarly, an increase in the Value Added Tax (VAT) rate tends to increase revenue collection, given that it increases the percentage applied to the taxable income of consumption. However, the magnitude of this effect will depend on consumer behavior and the level of tax compliance.

This study estimates the dynamic effect of legal complexity on VAT collection in Mexico. To do so, we incorporate key variables that were previously identified: Gross Domestic Product (GDP), periods of VAT rate increases, and times when tax amnesties were implemented. The analysis includes verifying the stationarity of the variables, checking for cointegration, and testing for Granger causality. This is all integrated into a vector autoregressive model, a feasible generalized least squares model, and an ARIMAX model.

The following presents a review of the existing literature on legal complexity and its possible relationship with other economic variables. The methodology used to analyze the relationship between legal complexity and the Value Added Tax Law is then detailed. The estimates obtained are presented, and finally, the conclusions are presented.

2. Literature Review

The study of legal complexity began in the late 20th century, when Long and Swingen (1987) proposed an indicator based on an instrument applied to tax law professionals, concluding that their instrument adequately reflected the experiences of the respondents. Schuck (1992) analyzed American tax law and defined a complex legal instrument as one with a high level of technical content, and where there is differentiation, uncertainty, and linguistic density.

Kades (1997) applied theoretical elements from mathematics and computer science to justify the complexity of tax regulations based on the concepts of dynamical systems. Epstein (1997) defined legal complexity based on the concept of compliance costs. A law is considered complex if it creates regulatory obstacles that hinder the achievement of a specific objective. Likewise, Diver (1983) concluded that a text is considered complex when it presents a low level of transparency, accessibility, and consistency. Consequently, a law is more complex to the extent that it lacks these three elements.

Kirchler (2007) agrees with Epstein's (1997) proposal, arguing that the difficulty in understanding the regulatory framework significantly increases the cost of compliance for taxpayers. This situation forces them to allocate more time and resources, or to hire specialized advice, which raises transaction costs. Consequently, he concludes that the greater the complexity of the legislation, the lower the rate of compliance with tax obligations by taxpayers.

Bourcier and Mazzega (2007) described legal complexity as a dynamic system characterized by the structure of the law, its content, and the density of the legal corpus. Relevant factors include the number of components, their interaction, partial knowledge of dynamic linkages, limited predictability of system evolution, and the constant incorporation of new components.

Subsequently, Katz and Bommarito (2014) measured the difficulty an individual has in understanding the legal framework, assuming that greater complexity generates a higher cost of compliance. They designed an indicator with three components: the structure of the legislation, the language used in the laws, and the interdependence between them.

Specifically, the indicator for measuring the complexity of legal texts, developed by Katz and Bommarito (2014), integrates three key components. Structure is measured by visualizing the law as a hierarchical tree diagram, where the depth of each element (such as articles or paragraphs) reflects its level of detail. Language is assessed based on the words that comprise that structure, considering aspects such as their length, meaning, and relative frequency. Within this framework, the language dimension can be equated with the concept of entropy in the legal text (Moreno, Beltrán, & Mata, 2017). Finally, interdependence is determined by the references a legal document makes to others, whether internal or external to the same law, which requires the reader to consult multiple texts for a full understanding.

In particular, the concept of entropy, which relates to the dimension of language, opens the door to multiple interpretations of the relationship between legal complexity and VAT collection. Initially, a link is established with Shannon's (1948) information theory and complex dynamical systems. In this context, Waltl and Matthes (2014) designed various structural indicators of lexicon and correlations, and concluded that the average length of a law's paragraphs correlates with readability and, therefore, with its level of complexity. Similarly, Ruhl and Katz (2014) distinguished complexity in terms of the confusion a person experiences when understanding a law. Furthermore, it can be stated that legal complexity increases as the dependencies between the

elements of a law increase, that is, when a change in one legal element affects other elements of the law and the element itself. Under this scenario, this resulting ambiguity, related to entropy and the language of the law, would be expected to have a negative effect on VAT collection.

Along these lines, Krever and Mellor (2015) studied the entropy and legal complexity of the United States tax law. The authors found that the cost of compliance with the law can be associated with the concept of legal complexity, which proposes modifying laws to make them easier to understand and comply with. This proposal to reduce the degree of legal complexity suggests, in the authors' words, an expectation of efficient tax collection.

Now, a study that, like Katz and Bommarito (2014), employs the dimensions of structure, language, and interdependence to analyze a legal text is Espinosa and Álvarez (2022). The authors adhere to the entropy and information theory approach and assert that text is a raw material, where text mining tools allow patterns to be recognized in large volumes of text. This set of text analyses often leads to measures of legal complexity that have effects on economic and financial variables.

Specifically, in the case of Mexico, the work of Moreno et al. (2020) analyzed the impact of economic growth and the legal complexity of the VAT Law on VAT collection in Mexico, from 1980 to 2016. Their least squares model, fitted with a Box-Cox transformation, showed a positive relationship between economic growth and VAT collection, and a negative relationship between legal complexity and VAT collection. Subsequently, Moreno et al. (2023) investigated the relationship between VAT and tax complexity, finding an inverse relationship between legal complexity and VAT as a percentage of GDP. Of the complexity variables, the interdependence of the VAT law was the one that showed the most significant impact on tax collection.

In this sense, this research is an extension of the work carried out by Moreno et al. (2020; 2023), where the contribution of this study, in relation to what was found in the reviewed literature, consists of the dynamic estimation between legal complexity and VAT collection, which implies the robust calculation of the dynamic effect that these variables have in the short term.

In the following section, considering the literature review, the most appropriate methods to respond to the objectives of this research work are described.

3. Methodology

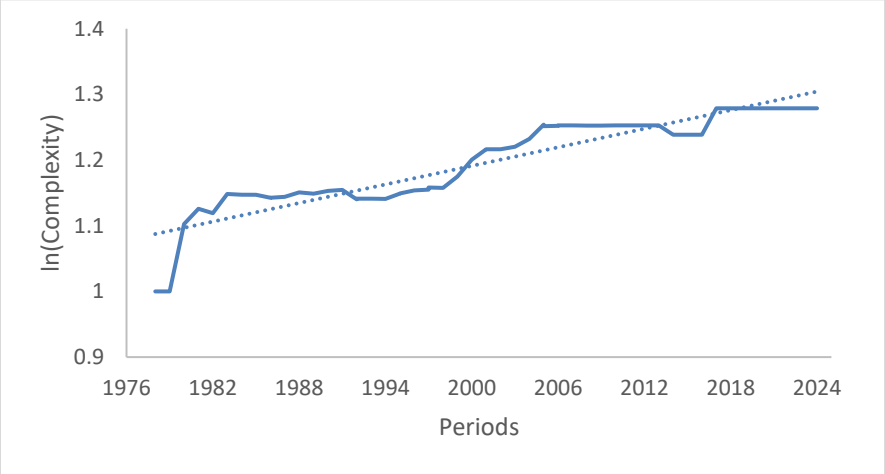
In this study, the legal complexity indicator of the VAT Law addresses the dimensions of structure, language, and interdependence identified by (Katz & Bommarito, 2014), although adapted to the Mexican case by (Moreno, Beltrán, & Mata, 2017). The structure component was based on the hierarchical organization of the text. A numerical weighting from 1 to 5 was assigned to each element (article, paragraph, section, subsection, and numeral) according to its depth, allowing for the identification of additions and repeals made to the Law throughout the reference period, in each of the quarters.

The language dimension was analyzed from the perspective of information theory and entropy. Basically, text mining techniques were used to measure the relative frequency of each word in the versions of the VAT Law published between 1978 and 2024. The measurement scale starts with a value of zero, which indicates a uniform text, while the maximum value suggests a non-uniform text, relative to the 1978 version of the VAT Law.

Furthermore, the interdependence component was generated by considering the degree of reference made between paragraphs of the VAT Law or to another law in each quarter of the reference period. That is, weights ranging from 1 to 4 were assigned, with 1 corresponding to the

simplest reference (to a previous paragraph) and 4 to the most complex (to another law), under the assumption that the difficulty of understanding increases with the type of reference.

Figure 1. Legal complexity



Note: The reference period for the legal complexity index is 1978.

Source: own elaboration.

Furthermore, the interdependence component was generated by considering the degree of reference made between paragraphs of the VAT Law or to another law in each quarter of the reference period. That is, weights ranging from 1 to 4 were assigned, with 1 corresponding to the simplest reference (to a previous paragraph) and 4 to the most complex (to another law), under the assumption that the difficulty of understanding increases with the type of reference.

The legal complexity indicator LC_t was estimated by summing the logarithmic values of the initial components of structure, language and interdependence.

$$LC_t = LE_t + LL_t + LI_t, \quad t = 1,2,\ldots,T \tag{1}$$

where LE_t is the natural logarithm of the structure dimension, LL_t is the natural logarithm of the language dimension, and LI_t is the natural logarithm of the interdependence dimension.

The objective is to find evidence of a relationship, both in the short and long term, between legal complexity and VAT collection. To do so, the quarterly time series of the Mexican Value Added Tax (VAT) for the period 1978–2024 is used. This time series was seasonally adjusted using Tramo Seats software (Eurostat, 2024) and the natural logarithm was taken, $LVAT_t$.

Similarly, the quarterly time series of the Gross Domestic Product in natural logarithm and seasonally adjusted, $LPIB_t$, and two exogenous variables $BREAK_t$ and $TAXAMNESTY_t$, defined as follows, are considered:

$$BREAK_t = \begin{cases} 1 & si\ t = 1980, 1983, 1995, 2010 \\ 0 & otro\ caso \end{cases} \tag{2}$$

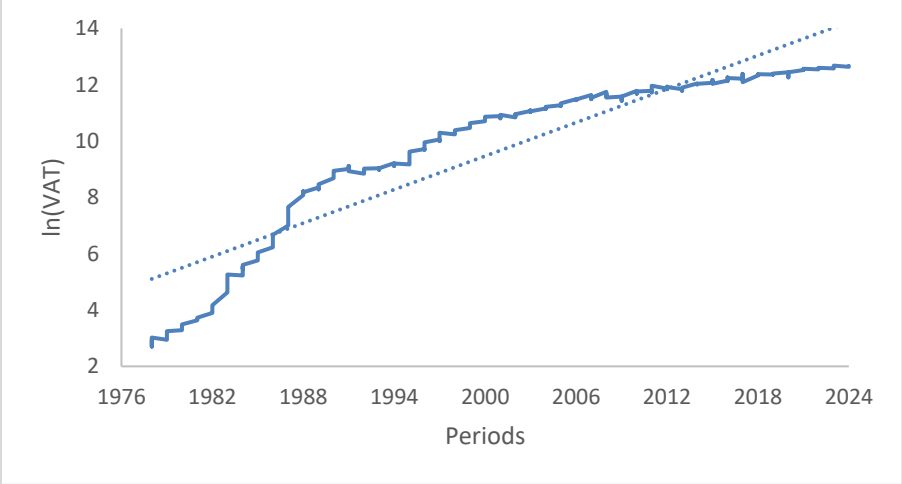
where 1980, 1983, 1995 and 2010 correspond to the years in which the VAT tax rate was increased.

The dichotomous variable $BREAK_t$ indicates the years in which the VAT rate was increased and the binary variable $TAXAMNESTY_t$ indicates in which years relevant federal tax forgiveness was presented.

$$TAXAMNESTY_t = \begin{cases} 1 & si\ t = 2007, 2013 \\ 0 & otro\ caso \end{cases} \quad (3)$$

For the set of estimates performed, the stationarity of the time series was first verified in terms of levels and first differences. Various cointegration tests were then applied to determine whether the estimation of an error correction model was justified.

Figure 2. VAT collection



Source: own elaboration.

Based on the results, the optimal number of lags for the VAR/VEC model was estimated. Granger causality, model assumptions, and the significance of the obtained coefficients were then evaluated (see appendixes).

To strengthen the results presented, various econometric models were estimated, including a time series regression model, an ARIMA model with exogenous variables, a vector autoregression (VAR) and a vector error correction (VEC), as appropriate.

Formally, the k-order VAR model is defined as:

$$\Delta LVAT_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i}\, \Delta LVAT_{t-i} + \sum_{i=1}^{k} \alpha_{2i}\, \Delta LGDP_{t-i} + \sum_{i=1}^{k} \alpha_{3i}\, \Delta LC_{t-i} + \sum_{i=1}^{m} \alpha_{4i}\, X_{t-i} + \varepsilon_{1t} \quad (4)$$

$$\Delta LGDP_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i}\, \Delta LVAT_{t-i} + \sum_{i=1}^{k} \beta_{2i}\, \Delta LGDP_{t-i} + \sum_{i=1}^{k} \beta_{3i}\, \Delta LC_{t-i} + \sum_{i=1}^{k} \beta_{4i}\, X_{t-i} + \varepsilon_{2t} \quad (5)$$

$$\Delta LC_t = \gamma_0 + \sum_{i=1}^{k} \gamma_{1i}\, \Delta LVAT_{t-i} + \sum_{i=1}^{k} \gamma_{2i}\, \Delta LGDP_{t-i} + \sum_{i=1}^{k} \gamma_{3i}\, \Delta LC_{t-i} + \sum_{i=1}^{k} \gamma_{4i}\, X_{t-i} + \varepsilon_{3t} \quad (6)$$

where $\Delta LVAT_t, \Delta LGDP_t, \Delta LC_t$ are the first differences of the endogenous variables and X_t represents the exogenous variables, specifically the binary variables $BREAK_t$ and $TAXAMNESTY_t$. This VAR(k) model was estimated using robust standard errors consistent with heteroskedasticity and autocorrelation in the residuals (HAC).

The equation corresponding to the collection of the Value Added Tax, $\Delta LVAT_t$, was also estimated using an $ARIMAX(p, d, q)$ model with exogenous variables, given by

$$\Delta LVAT_t = \beta_0 + \sum_{i=1}^{p} \beta_{1i}\, \Delta LVAT_{t-i} + \sum_{i=1}^{m} \beta_{2i}\, \Delta LGDP_{t-i} + \sum_{i=1}^{r} \beta_{3i}\, \Delta LC_{t-i} + \sum_{i=1}^{s} \beta_{4i}\, X_{t-i} + \sum_{i=1}^{q} \beta_{5i}\, u_{t-i} \quad (7)$$

which considers standard errors that are robust to heteroskedasticity.

In addition, to strengthen the results, a feasible generalized least squares (GFMS) model with robust Newey-West standard errors was estimated, which is represented by the following equation:

$$\Delta LVAT_t = \gamma_0 + \sum_{i=1}^{h} \gamma_{1i}\, \Delta LVAT_{t-i} + \sum_{i=1}^{w} \gamma_{2i}\, \Delta LGDP_{t-i} + \sum_{i=1}^{z} \gamma_{3\mathrm{i}}\, \Delta LC_{t-\mathrm{i}} + \sum_{i=1}^{g} \gamma_{4\mathrm{i}}\, X_{t-\mathrm{i}} + v_t \quad (8)$$

The objective of performing the three estimates mentioned above, under the previous specifications, is to strengthen the conclusions and results obtained to support the dynamic relationship between legal complexity and VAT collection during the reference period.

The following section presents the estimates and their corresponding interpretation based on the previously discussed procedures and algorithms.

4.- Results and discussion

Table A1 in the appendices presents the results of performing the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), Zivot-Andrews (ZA), and Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) unit root tests on the variables LGDP, LC, and LVAT, both in levels and first difference.

It can be observed that at least with a 90% confidence level, the null hypothesis of non-stationarity is not rejected for ADF, ZA, and PP for the variables in levels, while it is rejected for the variables ΔLGDP, ΔLC and ΔLVAT. Similarly, in the KPSS test, the base hypothesis of stationarity is rejected for the time series in levels and is rejected for the differenced variables. Overall, there is evidence that the LGDP, LC, and LVAT time series are integrated of order one, I(1).

Given the non-stationary nature of the endogenous variables, it was decided to analyze whether they exhibit any cointegration relationship and verify whether there is long-term equilibrium. To this end, Table A2 of the Appendices presents the results of the Johansen, Engle-Granger, Phillips-Ouliaris, and Pesaran, Shin, and Smith cointegration tests (Lütkepohl, H., & Krätzig, 2024).

The results of the cointegration tests fail to reject the null hypothesis of no cointegration. In each of these tests, no evidence is found to support a long-term relationship for the variables LGDP, LVAT, and LC. Certainly, LVAT and LGDP would be expected to exhibit a cointegrating relationship, but legal complexity (LC) does not exhibit such behavior.

The lack of cointegration in the reference period can be explained by the fact that regulatory changes do not result in permanent adjustments to the VAT rate or its revenue. This is because the VAT has been subject to short-term political changes at different periods in the country's history. However, common short-term movements have been detected, supporting the link estimated in this study. This indicates that the estimates are carried out only in the short term, under the aforementioned VAR, GCF, and ARIMAX(p,d,q) specifications.

Table 1 shows the results of the previously discussed models. It can be observed that optimal lags lead to a one-period lagged effect of legal complexity on VAT collection. The coefficient associated with this impact is less than zero in all three specifications, providing evidence of an inverse relationship between these variables. Since the variables are in natural logarithm, the

corresponding coefficient can be interpreted as an average elasticity. In this case, the average percentage effect of the three models between legal complexity and VAT collection is -9.1%.

Table 1. Estimates of the specified models.

Variable	VAR (HAC standard errors, lags=1)	MCGF (Newey-West, lags=1)	ARIMAX(1,1,2) (robust standard errors)
$\Delta LVAT_{t-1}$	-0.226***		
	(0.067)		
$\Delta LGDP_{t-1}$	0.703***	0.611***	0.544***
	(0.111)	(0.142)	(0.177)
ΔLC_{t-1}	-0.086**	-0.088**	-0.099**
	(0.034)	(0.041)	(0.049)
$BREAK_{+}$	0.017	0.064*	0.055*
	(0.03)	(0.033)	(0.027)
$TAXAMNESTY_{t-1}$	0.075***	0.021*	0.017*
	(0.027)	(0.012)	(0.01)
$CONSTANT$	0.018*	0.013	0.015***
	(0.01)	(0.009)	(0.016)
$AR(1)$			0.968***
			(0.034)
$MA(1)$			-1.277***
			(0.088)
$MA(2)$			0.349
			(0.073)
σ			0.095
			(0.006)
R-squared	0.224	0.176	
Logverosimilitud	598.87		174.57
Observations	186	186	186

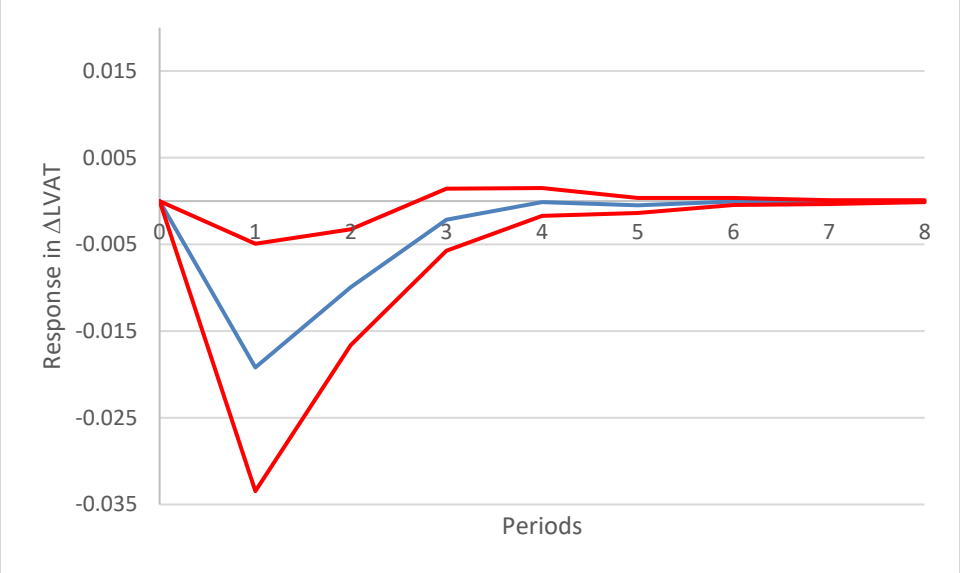
Note: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Source: own elaboration.

It is relevant to note that the expected signs are present in the rest of the variables: a positive effect of GDP on VAT collection, an increase in VAT collection when there is an increase in the tax rate (coefficients in $BREAK$) and an effect greater than zero of tax forgiveness, represented in this case by $TAXAMNESTY$.
Figure 3 presents the impulse-response function, where a random shock of one standard deviation is applied to the legal complexity variable (ΔLCt) and the response of the variable ΔLIVAt is observed over 8 periods. The shock generates an initial negative response, followed by a partial recovery, and the effect dissipates completely towards the end of the time horizon. Since the 95% confidence intervals do not include zero in the early periods, it can be inferred that the negative effects are statistically significant.

Previous estimates support this research hypothesis: the effect of legal complexity on value-added tax is negative and there is no long-run relationship. A 1% increase in the level of complexity in period t is expected to reduce VAT by 9.1% in period t+1, based on the average level of the coefficients estimated in the VAR, MCGF, and ARIMAX models. These findings highlight the importance of language (entropy), structure, and interdependence in VAT legislation and provide elements to suggest changes in the design of VAT law and its regulations, in order to avoid a negative impact on VAT collection.

Figure 3. Impulse-response function



Source: own elaboration.

Likewise, an increase in legal complexity indicates greater difficulty in collecting VAT and implementing public policies, which in turn increases legal compliance costs. This inverse relationship between VAT collection and legal complexity can be attributed to the fact that legislation is often imprecise, poorly formulated, or overly technical. This occurs because it frequently responds to short-term political circumstances rather than long-term fiscal planning that considers the specificities of the Mexican context. Therefore, the problem lies not in legal tradition, but in a political vision that prioritizes the short term.

5. Conclusions

The complexity index analysis shows an upward trend since the enactment of the VAT Law in 1978. This complexity arises from the additions and modifications made to the legal framework since its publication and throughout its 46 years of validity.

The complexity index integrates three dimensions of the VAT Law: language (legal entropy), rule interdependence, and law structure. In fact, this study estimated three different specifications to robustify the results: feasible generalized least squares, an ARIMA model with exogenous variables, and a vector autoregression model with the corresponding impulse response function. The set of estimates performed confirms the existence of an inverse dynamic relationship between legal complexity and the value-added tax. Quantifying this relationship contributes to the study of the VAT Law in Mexico under non-economic factors, since legal complexity represents a relevant factor, but one indirectly linked to economic activity.

The dynamic effects of the level of legal complexity on the VAT are more short-term than long-term, as confirmed by unit root tests, which show that the time series are not stationary across levels and that there is no cointegration. No evidence of a long-term equilibrium relationship is found. In this regard, it should be emphasized that the contribution of this study to the literature focuses precisely on the dynamic estimation of the two variables, legal complexity and VAT collection, as there are previous studies, but they focus on a contemporary time series horizon.

Finally, it is important to note that this study has some limitations. The estimates are robust only in the short term; there is no statistical evidence to support long-term conclusions. In this regard, future research could explore other estimation techniques for comparison purposes. For example, entropy indices for the language dimension based on information theory but with different approaches than Shannon (1948), such as the Rényi or Tsallis entropy metrics, could be used. Likewise, the Hoover or Kullback-Leibler indices could be used for comparison and contrast purposes for the complexity index. This would allow the study to be extended to other countries or to other legislations within the Mexican legal framework.

6. Appendixes

Table A1. Unit root tests

Variable	ADF	PP	KPSS	ZA
LVAT	-1.19	-1.18	4.14	-3.08
	(0.913)	(0.914)	(0.000)	(0.129)
LC	-2.91	-2.88	1.59	-3.51
	(0.158)	(0.168)	(0.000)	(0.175)
LGDP	-2.92	-2.34	3.91	-3.32
	(0.155)	(0.413)	(0.000)	(0.146)
ΔLVAT	-17.41	-16.9	0.08	-6.2
	(0.000)	(0.000)	(0.245)	(0.000)
ΔLC	-18.52	-18.64	0.11	-18.89
	(0.000)	(0.000)	(0.139)	(0.000)
ΔLGDP	-9.85	-10.32	0.19	-7.21
	(0.000)	(0.000)	(0.217)	(0.000)

Source: own elaboration.

Table A2. Cointegration tests

Number of cointegrating equations	Trace statistic	Max-Eigen statistic
None	10.18	11.39
At most 1	12.79	12.76
At most 2	0.03	0.04

Test	Statistic	p-value
Engle-Granger	0.63	0.375
Phillips-Ouliaris	9.86	0.256
Pesaran, Shin y Smith	3.09	0.109

Note: ***, ** and * indicate the null hypothesis of no cointegration is rejected at 1%, 5% and 10% significance levels, respectively.

Source: own elaboration.

Table A3. Optimal lags of the VAR model

Lags	LR	AIC	HQIC	SBIC
0		-5.531	-5.595	-5.443
1	409.34	-7.494	**-7.281***	**-6.968***
2	36.077	-7.418	-7.027	-6.454
3	34.951	-7.336	-6.767	-5.933
4	**90.792***	**-7.559***	-6.812	-5.717

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Table A4. Granger causality test

Relation			chi2 statistic	df	p-value
$\Delta LVAT_t$	vs	ΔGDP_t	40.11	1	0.000
ΔVAT_t	vs	ΔLC_t	1.61	1	0.206
$\Delta LGDP_t$	vs	$\Delta LVAT_t$	32.29	1	0.000
$\Delta LGDP_t$	vs	ΔLC_t	0.96	1	0.326
ΔLC_t	vs	$\Delta LVAT_t$	3.43	1	0.064
ΔLC_t	vs	$\Delta LGDP_t$	0.71	1	0.401

Source: own elaboration.

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