Elasticities of VAT Collection and Mexican Imports: Analysis by subchapters in the period 2010-2022

Elasticidades de la recaudación del IVA y las importaciones mexicanas: análisis por subcapítulos en el período 2010-2022

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Abstract

This article obtained the elasticities of the Value Added Tax (VAT) collection with respect to merchandise imports classified in the 689 subchapters of the International Harmonized System 2010-2022. Evidence of an equilibrium relationship, in the long run, was found by cointegration in a VEC model. The results show that 65 subchapters explain 80% of the value of imports with different elasticities, which allows identifying the sensitivity of VAT collection in generating income from imports. The subchapters that stand out are plastic tubes and accessories, (elasticity 1.4622), devices for cutting or connecting electrical circuits (elasticity 1.3542), rubber and inflatable joints (elasticity 1.3513), electrical ignition devices and devices for motors (elasticity 1.3340) and plastic containers (elasticity 1.3173). Elasticities allow calculating increases in VAT collection due to movements in the value of imports, such as increases in VAT of US$ 212 million due to movements in the import of machinery, appliances, and mechanical devices.

Keywords: *VAT, taxes, imports, cointegration.*
JEL Classification: *E62, C01, H30.*

Resumen

Este artículo obtuvo las elasticidades de recaudación del impuesto al valor agregado (IVA) respecto de las importaciones de mercancías clasificadas en los 689 subcapítulos del Sistema Armonizado Internacional 2010-2022. La evidencia muestra una relación de equilibrio a largo plazo, determinada mediante un modelo VEC por cointegración. Los resultados señalan que 65 subcapítulos explican el 80% del valor de las importaciones con diferentes elasticidades, lo que permite confirmar la relación positiva entre las importaciones y la recaudación del IVA. Los subcapítulos que destacan su sensibilidad son: tubos y accesorios de plástico, (elasticidad 1.4622), dispositivos para cortar o conectar circuitos eléctricos (elasticidad 1.3542), juntas de caucho e inflables (elasticidad 1.3513), dispositivos de encendido eléctrico y dispositivos para motores (elasticidad 1.3340) y plásticos contenedores (elasticidad 1.3173). Las elasticidades permiten calcular los incrementos en la recaudación del IVA ante movimientos en el valor de las importaciones; tal es el caso de incrementos en el IVA de 212 MDD ante movimientos en la importación de maquinaria, aparatos y artefactos mecánicos.

Palabras clave: *IVA, impuestos, importaciones, cointegración.*
Clasificación JEL: *E62, C01, H30.*

1. Introduction

Governments increasingly seek to preserve the strength of public revenues. To this end, they engage in different actions that seek to simplify the tax framework and achieve better compliance in the payment of taxes, which, in addition to proper behavior of the economy, lead to greater income, allowing governments to channel resources to education, health, security and protection activities, among others.

To increase public income, tax collection must be improved. Therefore, it is necessary to carry out a range of income estimation exercises for each of the taxes administered by a government, in such a way that they enable it to secure more resources for the proper fulfillment of its public functions as a State.

In terms of estimating tax revenues, the International Monetary Fund (IMF) recommends a method that uses the concept of elasticity and that measures the magnitude of the reaction of a consequence variable to a shock in an antecedent variable and, depending on the magnitude of the reaction, defines whether the behavior of the consequence variable is elastic or inelastic (IMF, 2001). Defining whether a variable has elastic or inelastic behavior determines tax policy decisions, since if a decision is made that affects the antecedent variable, the reaction could be significant in a positive sense, but also in a negative sense. Therefore, we must know the magnitude of the possible reactions for each of the elements that impact the changes in the consequence variable.

For the purposes of this research, the antecedent variable is the 689 subchapters that make up the 99 chapters into which imports are classified within the International Harmonized System. The consequence variable is the collection of Value Added Tax (VAT) derived from the import of goods.

Studying this relationship is important because, firstly, the income generated by the collection of VAT is the second highest source of tax income for the Federal Government, only surpassed by the collection of Income Tax, and secondly, because most of the VAT collection is through imports of goods.

Desai and Hines (2002) stated that VAT collection represents one of the most important sources of revenue for governments around the world, except for the United States of America which utilizes a sales tax. The authors stated that, during the last half of the last century, VAT was adopted by most countries around the world, playing a primary role in developing economies, to the extent that VAT collection represented, on average, a quarter of government revenue.

Ordinarily, in Mexico, goods imports are taxed at a rate of 16% and, being such an important source of tax revenue, it is worth identifying the drivers of variations in VAT collection arising from goods imports. Identifying the types of imports that have the greatest sensitivity to VAT collection, and obtaining their elasticity as a metric of sensitivity, contributes to improving the auditing of the import of goods into national territory and therefore improves oversight of the collection of this tax.

Wawire (2017) established that VAT has the advantage that, in order to be collected, the State doesn't have to carry out any specific action; the only requirement is consumption by citizens. It is this characteristic that provides VAT with a certain degree of stability and elasticity; that is, VAT does not generate very many administrative costs in order to be collected.

Estimating the elasticity of VAT collection in relation to movements in goods imports facilitates the estimation of the income derived from this tax. This supports the preparation of the income budget that governments must carry out to exercise their public responsibilities.

Therefore, the purpose of this article is to identify the subchapters of imports that present greater sensitivity to the collection of VAT from foreign trade, in order to determine the main economic activities that could support an increase in VAT collection arising from changes in the value of imports. The determination of these items is made by estimating the elasticity of VAT collection with respect to changes in the value of imports of the 689 subchapters used to record the import of goods into Mexico.

Before presenting the results of the research, we offer some background on works that have analyzed the behavior of tax revenues and have used the elasticity methodology to forecast revenues with a lower degree of uncertainty, in order to reduce variability in the collection of tax revenues.

2. Documentary review

In order to strengthen the approach used in this article, some prior research is presented that shows the advantages of using one of the methods recommended by the IMF for estimating the public income of governments, and that refers to the use of the concept of elasticity to estimate the behavior of tax revenues, in this case, revenues from VAT collection.

Jenkins et al. (2000) stated that all countries in the process of preparing their budget must make projections of their tax revenues. They used the concept of fiscal elasticity, defined as the relationship between the rate of variation of tax revenue and the rate of variation of income or GDP, assuming that there are no arbitrary changes in the tax rate or tax base. Using this concept, they determined that when an increase in tax income is recorded, it may be inferred that both the tax policy and the tax administration are performing well over time.

Skeete et al. (2003) concluded that the elasticity of a tax system measures the response of tax revenues to changes in national income, assuming all other parameters (including tax legislation) remain constant. When the elasticity of the main sources of revenue is low (for example, due to the rigidity of the tax base or the presence of tax evasion and/or avoidance), governments obtain additional resources through discretionary measures. When rigidity is observed in the tax base, the growth of tax revenues is due more to the dynamism of economic activity than to high elasticity.

Stánicá (2013) established that, for a government to grow, it is vital that it achieves stability. This can be measured based on how accurate public spending and income forecasts are; therefore, it is very important for a State to have a good financial projection system that reflects the behavior of tax collection based on the real behavior of economic indicators such as imports. Using the elasticity method for VAT collection with respect to imports, it was concluded that a country can grow when its tax collection grows in relation to the growth of its imports.

Dudine and Jalles (2017) established that the use of the tax elasticity calculation methodology is more suited to estimating the impact on tax revenues from unexpected falls in the tax base resulting from natural disasters, unforeseen variations in the tax base, or variations in income as the basis for calculating income tax, as long as other provisions (income level, deductions and allowances) remain the same.

Gumbo and Dhliwayo (2018), using the exponential smoothing method and an elasticity estimation approach, studied fiscal buoyancy in VAT collection and concluded that adopting a systematic VAT revenue forecasting approach and isolating the income estimation process from the political context allows the income derived from VAT to be calculated with greater clarity and precision, confirming that every tax must observe the principle of certainty in order to improve its administration and collection.

Using regression analysis, Todorović et al. (2021) studied the factors that affect the efficiency of VAT collection in Serbia and found a positive correlation between the growth rate of Gross Domestic Product (GDP) and the behavior of VAT collection. The authors concluded that the higher the VAT rate, the less likely it is that taxpayers will comply with payment, meaning that a rate that does not change and is not too high ensures that taxpayers will pay the rate they owe. This conclusion is in line with what is theoretically established by the Laffer curve, which states that raising the tax rate does not necessarily increase tax revenue (Casparri and Elfenbaum, 2016).

Ofori et al. (2020) studied the behavior of budget revenues in Ghana and, by comparing two estimation methods (ARIMA and HOLT), concluded that the ARIMA method was the most accurate for correctly predicting VAT revenue. As a result, the government of Ghana was able to predict its revenues more accurately and thereby achieve a precise and effective fiscal plan. An accurate revenue budget is vital for a government to understand how to improve its economic planning; currently there is no consistent method that can be adjusted to all scenarios and that reflects reality.

Timsina (2020) measured the elasticity and buoyancy of VAT in Nepal to determine whether the tax system was elastic or inelastic. Their conclusion was that, for the period 1975-2005, the tax system was inelastic (less than one), meaning that most revenue collection was generated by discretionary changes in tax policy, rather than automatic responses. In emerging economies there is a desire for a tax system that makes it possible to balance expenditure and income projections. Estimating elasticities can contribute to meeting this concern, since it allows greater certainty about public income forecasts, as was the case in Ghana.

In South Africa, the behavior of tax revenues was studied through the regression method and with the use of time series. Makananisa (2020) found that state revenue collection is very sensitive to various economic variables, leading to the conclusion that VAT collection does not grow or fall without being linked to another economic factor such as imports. This positions this indicator as one of the concepts that permit better estimation of tax revenues for the South African government.

Shala (2017) studied the ratio of tax revenue to GDP in Kosovo and determined that it has been low compared to other countries in Europe, reflecting a low level of economic development. However, they stated that even with this limited development in the country, the correlation between VAT and GDP is a positive one,

which means that increasing one variable increases the other. Therefore, it was concluded that VAT has a significant impact on the economic growth of Kosovo.

From the literature review, we may conclude that there is a consensus view that the relationship between VAT collection and GDP is positive. The method recommended by the IMF for estimating government budget revenues by calculating elasticities of tax collection with respect to the behavior of the tax base is very useful, since it leads to greater certainty in the preparation of government budgets. Above all, however, it provides a way of estimating possible decreases in tax collection in response to negative variations in the tax base of the different forms of tax.

3. Econometric Analysis

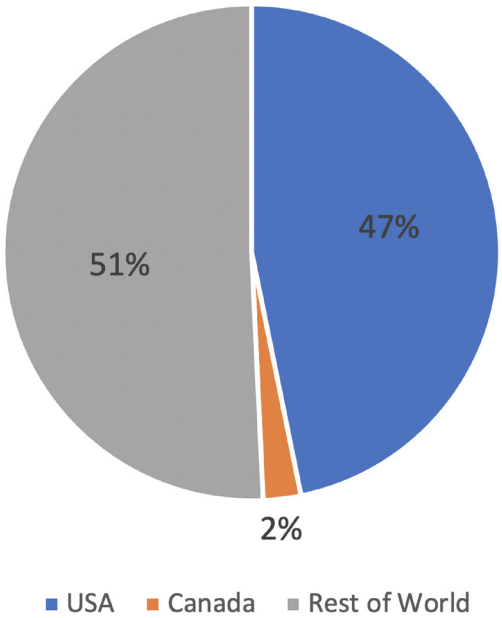
Imports of goods from Mexico during the years 2021 and 2002 reached the value of US$ 505.7 and 604.6 billion respectively. Of this latter figure recorded in 2022, 43.8% come from the United States, 2.2% from Canada, and the remaining 54% refers to imports from the rest of the world. Over the period from 2010 to 2022, the average of imports originating from the United States represented 46.8%, Canada, for its part, recorded an average of 2.4%, and the rest of the world had an average participation of 50.7%.

During these two years (2021 and 2022), imports grew by 32 and 19.6%, exceeding the value of imports recorded in 2019 prior to the COVID-19 pandemic. These figures indicate the recovered dynamism in imports of goods by the Mexican economy. During the period 2010-2022, the average annual growth rate of imports was 5.9%, a figure higher than for GDP in 2010, the year with the highest growth figure for GDP (5.1%) in the study period (World Bank, 2023).

In 2022, total Mexican imports amounted to US$ 604.6 billion. The five main countries exporting goods to Mexico were: the United States of America, with 43.9%; China, with 19.6%; Republic of Korea, with 3.7%; Germany, with 3.1%; and Japan, with 3.0%. Together, these five countries represented 73.3% of all imports made by Mexico in 2022. Canada, in eighth place, has a share of 2.2% of the total imports made that year.

Figure 1 shows that in terms of imports from Mexico's trading partners in the Mexico, United States and Canada Free Trade Agreement (USMCA), during the 2010-2022 period, 46.8% on average came from the United States of America and 2.4% originated in Canada; the remaining 50.7% of imports came from the rest of the world (see figure 1).

Figure 1. Average percentage composition of Mexican imports (2010-2022)



Source: prepared by the authors with data from TradeMap.

In terms of products, the five main products originating from the United States of America were the following: Mineral fuels, mineral oils and their distillation products; bituminous materials, with a 21.5% share; Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof, with 11.9%; Electrical machinery and equipment and parts thereof; sound recorders and reproducers, with 8.8%; Motor vehicles, tractors, cycles and other land vehicles, their parts and accessories, with 8.0%; and Plastic and manufactured products, with 7.6%.

Canada exported goods to Mexico in five main chapters: Motor vehicles, tractors, cycles and other land vehicles, their parts and accessories, with 16.6%; Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof, with 9.6%; Miscellaneous chemical products, with 9.2%; Oilseed seeds and fruits; various seeds and fruits; industrial or medicinal plants, with 7.6%, and Electrical machinery and equipment and parts thereof; sound recorders and reproducers, with 6.4%.

The main categories of Mexican imports from USMCA partners represented 57.9% in the case of the United States of America, and 49.4% in the case of Canada. Three chapters appear for both countries: Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof; Electrical machinery and equipment and parts thereof; sound recorders and reproducers; and Motor vehicles, tractors, cycles and other land vehicles, their parts and accessories.

The equivalent chapters in Mexico's imports from its trading partners in the USMCA represent 7.0%, 6.5% and 6.4% respectively, as a proportion of GDP. Likewise, imports are taxed with tariffs ranging from exempt to 5%, 10%, 15%, 20% and 50%, which means that they are sensitive activities for the Mexican economy, given their participation in GDP.

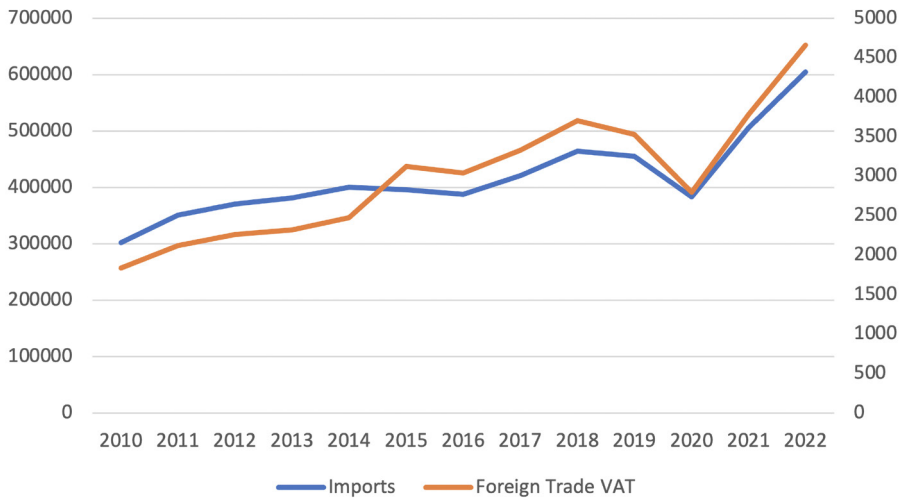
In terms of VAT, in Mexico imports of merchandise are taxed at a rate of 16%, and VAT represents the second highest source of tax income, with imports being the principal source of collection of this tax at the time of importation into national territory of goods from abroad.

During 2022, total VAT collection reached 1,221.8 billion pesos at current value, which represented a 32.1% share of total annual tax revenues. In the same year, VAT collection from foreign trade amounted to 937.4 billion pesos, which represented 76.7% of the total VAT collected. In the period 2010-2022, VAT revenues represented on average 33.7% of the Federal Government's tax revenues; in this same period, VAT derived from imports of goods represented on average 63.3% of the total VAT collected (SAT, 2023).

The VAT derived from foreign trade operations, converted to dollars, amounted to US$ 47.6 billion in 2022. This amount is the highest recorded during the analysis period (2010-2022). The average annual growth rate of VAT collection from foreign trade was 8.1%, higher than that recorded by imports of goods during the same period.

Figure 2 shows the positive relationship between imports of goods and VAT collection from foreign trade operations; two significant points of inflection appear in the behavior of both indicators (see figure 2).

Figure 2. Value of imports and VAT collection from foreign trade 2010-2022 (millions of US dollars)



Source: prepared by the authors with data from SAT (2023), INEGI (2023) and Banxico (2023).

The first point, in the years 2014 and 2015, resulted from the 41st reform to the VAT Law, published in the Diario Oficial de la Federación (DOF, Official Gazette of the Federation) on December 11, 2013 and entering into force on January 1, 2014 (Ley del Impuesto al Valor Agregado, 2013), a reform that adjusted the tax rate in the border strip to bring it into line with the rate that applies in the rest of the country (16%). According to the Laffer curve, the relationship between tax revenues and tax rates changes when the rates change. That is to say, raising the tax rate does not necessarily increase revenue, because the tax base falls. At the point where the tax rate is zero, tax revenue will be zero since no tax is applied. On the contrary, if the tax rate is 100%, tax revenues will also be zero, since no one would agree to produce a good if the revenues it generates go entirely towards paying taxes. In general, the higher the rate, the greater the amount collected, although this principle is not always met; that is, the rate may increase but this does not lead to an increase in tax collection (Casparri and Elfenbaum, 2016).

Additionally, the 2013 reform considered other modifications such as eliminating VAT exemptions for the purchase, rental and mortgage payments of a home, teaching services, and entertainment. It also proposed eliminating the zero rate enjoyed by specific products such as chewing gum, pet food and jewelry. Another aspect that

supported the increase in the collection of VAT for goods imports, also established in the 2013 reform, was the elimination of the exemption for the payment of the tax on goods destined for the special customs regime that covers temporary imports for processing, transformation or repair in assembly plants or export; fiscal warehouses for vehicle assembly and manufacturing processes; production, transformation or repair in premises under fiscal control, and strategic premises under fiscal control. It established that companies should obtain certification annually from the tax authority in order not to hinder the importation of goods under these temporary regimes (Unda, 2015).

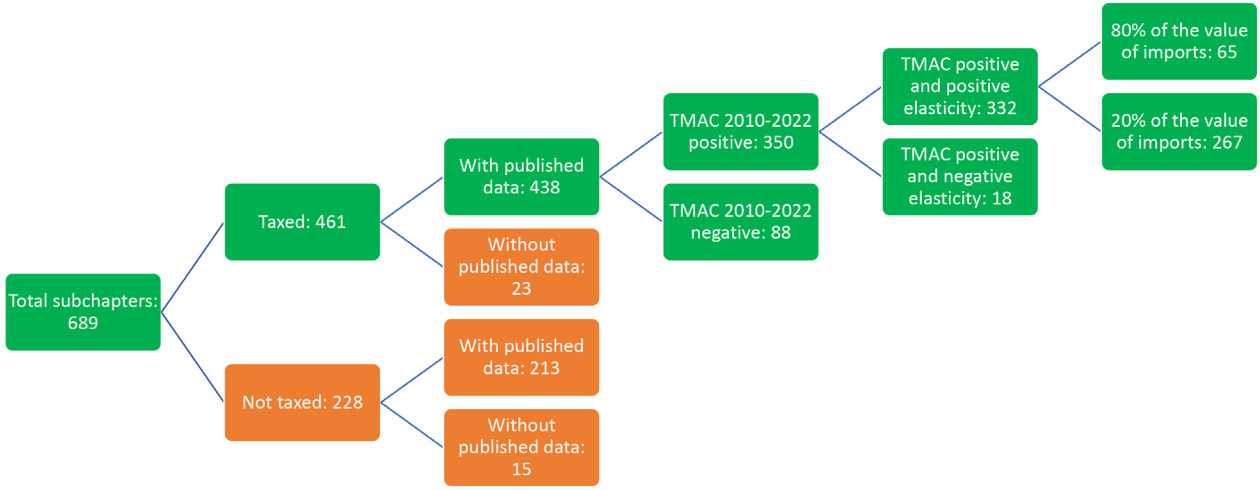
The second point of inflection is observed in 2020, with a drop in imports and VAT collection from foreign trade operations of 15.9% and 20.8% respectively. This drop was a consequence of the COVID-19 pandemic. However, by 2022 there was a recovery in both indicators equal to or greater than 20%.

Moreno and Mata (2022) analyzed the relationship between the value of imports and VAT collection by type of good (intermediate, final consumption, and capital goods), and concluded that the relationship between the import of goods and VAT collection is positive and inelastic. This means that the sensitivity is greater than zero, but less than one, which implies that when there is a percentage increase in the import of goods, the increase in VAT collection from foreign trade operations will be smaller in proportion.

This research seeks to identify the sensitivity of VAT collection with respect to imports made under the classification of the 689 subchapters of the general import and export tariff. That is, to analyze in greater detail the main subchapters that generate an impact on VAT revenues.

Figure 3 shows the composition of the subchapters. It can be observed that 65 of them are responsible for 80% of the value of imports of 2022. To identify these categories, imports that are taxed and that have data published in the official statistics of the Government of Mexico were analyzed in detail. Altogether, 228 subchapters were discarded from the analysis since they are not taxed in accordance with the Value Added Tax Law (Ley del Impuesto al Valor Agregado, 2013) and the General Import and Export Tariff (TIGIE). A further 23 were set aside that, although they are taxed, there is no published data because the imports carried out in these areas involve a single company and, due to data confidentiality, in accordance with the Law of the National Statistical and Geographic Information System (Ley del Sistema Nacional de Información Estadística y Geográfica (2008, 2015), the information is not published. Therefore, this analysis is limited to the 438 taxed subchapters with published data (see figure 3).

Figure 3. Composition of the subchapters of the International Harmonized System



Source: prepared by the authors with data from SAT (2023), INEGI (2023) and Banxico (2023).

The set of information variables was transformed using a natural logarithm and were seasonally adjusted using the Census X12-ARIMA method. The objective is to estimate the elasticities between the variables of the 689 subchapters and VAT collection in the long term since stable coefficients are sought to analyze the collection in the future.

To do this, a Vector Error-Correction (VEC) is estimated and the existence of cointegration is verified under the Johansen test, by means of the following steps:

a) Unit root tests to check whether the time series in levels or first difference are stationary variables.

b) Estimate the optimal lag for the Vector Autoregressive (VAR) associated with the VEC model, and which connects the total set of variables.

c) Carry out the Johansen test under different specifications to verify the existence of one or more cointegration vectors.

According to the first step, the order of integration of each of the items used was verified through the Augmented Dickey-Fuller (DFA), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) stationarity tests. The DFA and PP tests have as their base hypothesis the existence of a unit root, and the aim is to reject the null hypothesis. Meanwhile, the KPSS test takes the existence of stationarity as its null hypothesis, making the aim not to reject it H_0 (Lütkepohl, 2013). It can be seen that there is evidence to reject the null hypothesis in DFA and PP for all variables in first difference and that H_0 is not rejected for the KPSS test. That is, the data series are integrated of first order, I(1). In other words, the variables are non-stationary at levels with a unit root, and stationary at their first difference.

Then, as a second step, the Akaike (AIC), Schwarz (BIC), and Hanna-Quinn (HQIC) information criteria are used to evaluate the optimal lag for the underlying VAR model. Table 1 shows that the number of lags is one, which adjusts to the minimum values per column (see table 1).

Table 1. Optimal lags for the VEC model

Lags	AIC	HQIC	BIC
0	-11976	-11478	-11,734*
1	-12,661*	-11,878*	-9749

Lags	AIC	HQIC	BIC
2	-12597	-10331	-7017
3	-12581	-9229	-4331
4	-12658	-8221	-1739

Source: prepared by the authors.

Note: * indicates the optimal lag according to the information criterion with a 90% confidence level.

Considering the optimal lag equal to one, the Johansen hypothesis test is carried out, where the null hypothesis is H_0: There are no cointegration relationships. This test is important since we want to estimate the long-term elasticities.

Specifically, before estimating the parameters of a VEC model, the number of lags in the underlying VAR model, the trend specification and the number of existing cointegration equations must be chosen (Tsay, 2015).

In this research, three types of methods are implemented to determine r, the number of cointegration relations. The first procedure is the trace method, the second uses the maximum eigenvalue and the third minimizes the Schwarz information criterion (BIC). These three methods are based on the maximum likelihood estimator of the following equation:

$$\Delta z_t = \alpha(\beta' z_{t-1} + \mu + \rho t) + \sum_{i=1}^{p} \Gamma_i \Delta z_{t-i} + \gamma + \tau t + \varepsilon_t$$

where the parameters ρ, γ, τ and μ capture the trend and intercept elements, z_t is a vector $\kappa \times 1$ of non-stationary variables $I(1)$, α and β are coefficient matrices of size $\kappa \times r$ with , $0 < r < k$, Γ_i is a matrix $\kappa \times \kappa$ of parameters and ε_t is a vector $\kappa \times 1$ of normal random perturbations with zero mean and covariance matrix Ω.

Table 2 presents the possible cointegration relationships, according to the different specifications for the cointegration equation and for the VEC model equation that were feasible according to the complete Johansen test. The maximum eigenvalue method does not find evidence of cointegration since there are no significant cointegrating relationships. On the other hand, the trace method provides evidence of four cointegration vectors under different specifications, hence the case of linear trend in the VEC and intercept without slope in the cointegration equation is considered, since the BIC information criterion reaches its minimum value in four cointegration relations (see table 2).

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Table 2. Johansen test

Specification on non-stationary variables:	No trend	No trend	Linear Trend	Linear Trend	Quadratic Trend
Specification in the cointegration equation:	Intercept No slope	Intercept Slope	Intercept No slope	Intercept Slope	Intercept Trend

Test	Rank	Statistics				
Trace	3	**15.571***	37.1703	34.4578	48,5277	47.7684
	4	4.9275	**14.097***	**11.549***	**23.440***	22.9425
Maximum eigenvalue	3	10.6437	23.0732	22.,9078	25.0876	24.8259
	4	4.8553	9.2421	8.608	17.829	17.4733
BIC information criterion	0	**-8.253***	**-8.253***	-8.568	**-8.077***	-8.451
	4	-8.015195	-7.98188	**-8.795***	-7.847	-8.721

Source: prepared by the authors.

Note * indicates the significant case with a 90% confidence level.

With the specification indicated in Table 2, the VEC model is estimated and the cointegration vector that contains the stable long-term elasticities is found.

Specifically, the VEC model that has been estimated on a vector of non-stationary endogenous variables is defined as

$$\Delta z_t = B_0 + \Pi z_{t-1} + \sum_{i=1}^{p} \Gamma_i \Delta z_{t-i} + v_t$$

where Γ_i is an array of parameters of size $k \times k$, $\Pi = \alpha\beta'$ is a rank matrix $0 < r < k$ such that $\Gamma_i = -\sum_{j=i+1}^{j-p} Bj$ and $\Pi = -\sum_{j=1}^{p} Bj$ with p associated lags. The set of coefficients in the vector β correspond to the cointegration vector between the different variables and is the vector of fitted parameters (Lütkepohl, 2013).

In the estimation of the VEC model, three dummy variables are added: dummy24, dummy27 and dummy19. The variable dummy24 takes the value of one in the years 2014-2020 and zero otherwise, and seeks to capture the legal reform to article 24 of the VAT Law, which establishes that when goods are introduced into the country, and these are intended for temporary import customs regimes, they will be considered imports of merchandise.

The variable dummy27 considers the legal change to article 27 of the VAT Law, which establishes the value or tax base that will be taken into account for the importation of goods in the years 2016-2020. Meanwhile, the variable dummy19 captures the effect of the COVID-19 pandemic in 2020-2021.

The results of the developed model allow us to state that of the 438 subchapters with published data, 350 items showed an average annual growth rate during 2010-2022 of between 0.05% and 43.8%. The remaining 88 items showed a negative growth rate during the same analysis period. In the latter, the elasticity shown was negative, which shows us the positive relationship between imports of goods and VAT collection, the importation of goods into national territory decreases and the collection of value added tax decreases.

Of the 350 subchapters with positive growth, in 332 cases a positive elasticity was also recorded of between 0.0009 and 1.57, a figure that also allows us to affirm the positive relationship between the importation of goods and the collection of VAT. In 18 categories of the 350 analyzed, there was positive growth, but negative elasticities were recorded; that is, an inverse relationship, a situation that contrasts with the existence of a direct relationship between both concepts.

Within the 332 cases with positive growth and elasticity, there are 65 subchapters that explain 80% of total imports and that have a positive sensitivity on VAT collection; the following concepts stand out for their economic relevance: Petroleum coke, petroleum bitumen and other residues of petroleum oils or of oils obtained from bituminous minerals (share 8.78% and elasticity 0.4197); Parts and accessories of motor vehicles (share 6.14% and elasticity 0.9480); Electronic integrated circuits (share 5.48% and elasticity 0.8589), Special Classification Provisions (share 5.08% and elasticity 0.5870), and Petroleum gases and other gaseous hydrocarbons (share 3.64% and elasticity 0.4483). The remaining 267 concepts (of the 332 categories) account for 20% of total imports in 2022. Among the first five places, the following items stand out: Machines and devices for air conditioning (share 0.3462% and elasticity 0.5523); Instruments for automatic regulation (participation 0.3248% and elasticity 1.0066); Ball bearings, rollers, needles (share 0.3234% and elasticity 1.2063); Machines and apparatus for working rubber or plastic (share 0.3183% and elasticity 0.8029), and Parts for generators and electric converters (share 0.2944% and elasticity 0.9451).

4. Conclusions

From the analysis of the results, it can be concluded that in 88 categories that showed negative growth and elasticity, the positive relationship is fulfilled, in such a way that, to increase VAT collection, the import of goods should be encouraged in areas related to: Paper for domestic sanitary purposes; Synthetic fiber fabrics; Printing machines and apparatus; Flat photographic plates and films; and Parts for television recorders and transmitters.

In 18 categories, positive growth and negative elasticity were recorded, meaning the positive relationship between the importation of goods and the collection of VAT is broken. This should oblige the tax authority to carry out greater and better supervision of these 18 categories. The following subchapters stand out for their negative elasticity: Radio or television broadcasting devices (elasticity of -0.2147); Other stones and precious metals (elasticity of -0.1397); Rubber, natural gums and analogues (elasticity of -0.1038); Iron and steel profiles (elasticity -0.0887), and Precious metal or plated articles (elasticity -0.0764).

Of the items with positive growth and positive elasticity, there are 65 subchapters that, as already mentioned, explain 80% of imports, therefore, to encourage VAT

collection, the behavior of imports of Plastic tubes and accessories (elasticity 1.4622); Devices for cutting or connecting electrical circuits (elasticity 1.3542); Rubber and inflatable gaskets (elasticity 1.3513); Electrical devices and ignition devices for motors (elasticity 1.3340), and Plastic containers (elasticity 1.3173) would have to be monitored. Due to the magnitude of their elasticities, it can be concluded that the relationship is elastic and, as the import of goods increases, the collection of VAT would also increase.

It should be noted that in the 18 categories of positive growth and negative elasticity, it is possible to conjecture the existence of unfair practices for importing goods that have an impact on evasion or avoidance in the payment of the VAT.

These items confirm what was postulated by Skeete, Coppin and Boamah (2003), who stated that when the elasticity of the main sources of income is low (for example, due to the rigidity of the tax base or the presence of tax evasion and/or avoidance), governments obtain additional resources through discretionary measures. Therefore, VAT collection is being generated by the actions carried out by the tax administration rather than by movements in the tax base determined by the importation of goods.

In terms of Mexico's main partners in the USMCA, the United States of America and Canada export goods to Mexico in three main and coincident chapters between both nations, which are: Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof (chapter 84); Electrical machinery and equipment and parts thereof; sound recorders and reproducers (chapter 85); and Vehicles other than railway or tramway rolling stock, and parts and accessories thereof (chapter 87).

Through the estimation made by the elasticity method, for the United States of America, for these three chapters, there would be an average increase in VAT collection as follows: an increase of 1% in the value of imports of chapter 84 would result in an increase in VAT collection of 0.667%, which means that if imports from that country grow by US$ 318 million, tax income would increase by US$ 212 million. For chapter 85 indicators show that for every US$ 232 million increase in the value of imports, the VAT collection would be US$ 135 million, and finally in chapter 87 the metrics indicate that for each increase of US$ 212 million tax income would grow by US$ 88 million.

In chapter 87, coming from Canada, Mexico would have an increase of US$ 14 million in VAT collection for every 1% growth in vehicle imports; for chapter 84 referring to nuclear reactors, boilers, machinery and mechanical appliances, an increase of

US$ 8 million would be achieved for each uptick of 1% in the value of imports; and, finally, for chapter 85 related to electrical machinery and equipment, there would be an increase of US$ 5.5 million for a 1% increase in the value of imports as shown in Annex 1 (see Annex 1).

Due to their importance to the Mexican economy, the import tariffs in these chapters range from 5% to 50%, which means that the manufacturing industry is very sensitive to imports in these chapters. Therefore, a recommendation would be to evaluate the feasibility of a possible tariff reduction, without affecting the domestic industry, as a way to promote the growth of imports. In the event of damage to the domestic industry, the increase in VAT collection would have to be due to tax administration actions such as administrative facilities, improved processes and greater oversight.

Recommendations derived from the above analysis include the following in regard to chapters 84, 85, 87, 39, 38 and 12, which are key chapters for Mexico's relationship with the United States of America and Canada: analyze the management of maximum quotas, seasonal tariffs, reduction of tariffs on products in which Mexico is not self-sufficient; review of rates with countries with which free trade agreements have not been signed, and making non-tariff regulations more flexible in order to encourage the growth of imports.

With the elasticities determined by this research, it was possible to identify the sensitivity of VAT collection with respect to the subchapters of imports subject to this tax, a result that contributes to the process of estimating tax revenues for the government of Mexico, which as Makananisa (2020) explained, the use of the elasticities calculated by the South African government allowed it to make a better estimate of its income.

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Annex

Subchapters with positive growth rate and positive elasticity which explain 80% of imports

Subchapter	Elasticity	TMAC 2010-2022	Participation in M
Tubes, pipes and hoses, and fittings therefor (for example, joints, elbows, flanges), of plastics	1.4622	0.0486	0.37%
Flat panel display modules, whether or not incorporating touch-sensitive screens	1.3542	0.0539	1.71%
Natural rubber, balata, gutta-percha, guayule, chicle and similar natural gums, in primary forms or in plates, sheets or strip	1.3513	0.0463	0.39%
Insulated wire, cable and other insulated electrical conductors, whether or not fitted with connectors; optical fiber cables, made up of individually sheathed fibers	1.3340	0.0438	0.37%
Articles for the conveyance or packing of goods, of plastics; stoppers, lids, caps and other closures, of plastics	1.3173	0.0523	0.75%
Other uncoated paper and paperboard, in rolls or sheets, not further worked or processed	1.2999	0.0509	0.39%
Sheet piling of iron or steel, whether or not drilled, punched or made from assembled elements; welded angles, shapes and sections, of iron or steel	1.2896	0.0519	0.85%
Other articles of plastics and articles of other materials of headings	1.2867	0.0614	1.46%
Taps, cocks, valves and similar appliances for pipes, boiler shells, tanks, vats or the like, including pressure-reducing valves and thermostatically controlled valves	1.2555	0.0568	0.88%
Other engines and motors, and parts	1.2112	0.0429	1.71%
Printed circuits:	1.1665	0.0604	0.73%
Electrical transformers, static converters and inductors; power supplies for automatic data processing machines	1.1446	0.0614	1.17%

Subchapter	Elasticity	TMAC 2010-2022	Participation in M
Railway or tramway track construction material of iron or steel, the following: rails, check-rails and rack rails, switch blades, crossing frogs, point rods and other crossing pieces, sleepers (cross-ties), fish-plates, chairs, chair wedges, ties and other material specialized for jointing or fixing rails:	1.1363	0.0631	0.75%
Other tubes and pipes (for example, welded, riveted or similarly closed), having circular cross sections, the external diameter of which exceeds 406.4 mm (16 in.) of iron or steel	1.1265	0.0676	0.48%
Pumps for liquids, whether or not fitted with a measuring device; liquid elevators	1.1226	0.0599	0.59%
Electrical apparatus for switching or protecting electrical circuits, or for making connections to or in electrical circuits	1.1110	0.0624	1.71%
Calculating machines and pocket-size data recording, reproducing and displaying machines with calculating functions; accounting machines, postage-franking machines, ticket-issuing machines and similar machines,	1.0930	0.0533	2.46%
Other plates, sheets, film, foil and strip, of plastics non-cellular and not reinforced, laminated, supported or similarity combined with other materials:	1.0766	0.0649	0.60%
Ball or roller bearings	1.0705	0.0682	0.79%
Boards, panels, consoles, desks, cabinets and other bases, equipped with two or more apparatus	1.0655	0.0679	1.03%
Semiconductor devices; photosensitive semiconductor devices	1.0630	0.0682	0.96%
Electrical insulators of any material	1.0530	0.0320	0.40%
Converters, ladles, ingot molds and casting machines, of a kind used in metallurgy or in metal foundries	1.0372	0.0383	0.37%
Microphones and stands therefor; loudspeakers, whether or not mounted in their enclosures; headphones and earphones	1.0326	0.0401	0.36%

Subchapter	Elasticity	TMAC 2010-2022	Participation in M
Photographic (other than cinematographic) cameras; photographic flashlight apparatus and flashbulbs	1.0203	0.0489	0.38%
Producer gas or water gas generators, with or without their purifiers; acetylene gas generators and similar water process gas generators, with or without their purifiers	0.9908	0.0719	0.70%
Air or vacuum pumps, air or other gas compressors and fans; ventilating or recycling hoods incorporating a fan, whether or not fitted with filters; gas-tight biological safety cabinets, whether or not fitted with filters	0.9875	0.0631	0.96%
Other plates, sheets, film, foil and strip, of plastics	0.9783	0.0771	0.46%
Base metal mountings, fittings and similar articles suitable for furniture, doors, staircases, windows, blinds, coachwork, saddlery, trunks, chests, caskets or the like; base metal hat- racks, hat-pegs, brackets and similar fixtures; castors with mountings of base metal; automatic door closers of base metal; and base metal parts thereof	0.9603	0.0734	0.35%
Electrical machines and apparatus, having individual functions	0.9559	0.0612	1.49%
Parts and accessories of motor vehicles	0.9480	0.0595	6.14%
Polymers of vinyl chloride or of other halogenated olefins, in primary forms:	0.9405	0.0826	0.61%
Instruments and appliances used in medical, surgical, dental or veterinary sciences, including scintigraphic apparatus, other electro-medical apparatus and sight-testing instruments	0.9312	0.0696	0.84%
Tableware, kitchenware, other household articles and hygienic or toilet articles, of plastics	0.8994	0.0261	1.17%
Electronic integrated circuits	0.8589	0.0785	5.48%
Seats whether or not convertible into beds	0.8586	0.0657	0.49%
Other bars and rods, of iron or nonalloy steel	0.8569	0.0768	0.59%
Instruments and apparatus for measuring or checking the flow, level, pressure or other variables of liquids or gases (	0.8443	0.0876	0.40%

Subchapter	Elasticity	TMAC 2010-2022	Participation in M
Telephone sets, including smartphones and other telephones for cellular networks or for other wireless networks	0.8311	0.0231	3.43%
Electrical capacitors, fixed, variable or adjustable	0.8284	0.0679	0.42%
Polymers of propylene or of other olefins, in primary forms	0.8168	0.0519	0.50%
Centrifuges, including centrifugal dryers; filtering or purifying machinery and apparatus, for liquids or gases	0.8022	0.0317	0.86%
Mechanical appliances for projecting, dispersing or spraying liquids or powders; fire extinguishers, whether or not charged; spray guns and similar appliances; steam or sand blasting machines and similar jet projecting machines	0.7177	0.0989	0.86%
Flat-rolled products of iron or nonalloy steel, of a width of 600 mm (23.6 in.) or more, hot-rolled, not clad, plated or coated	0.6982	0.0768	0.64%
Flat-rolled products of iron or nonalloy steel, of a width of 600 mm (23.6 in.) or more, clad, plated or coated	0.6915	0.0500	0.55%
Unwrought aluminum	0.6749	0.0986	0.83%
Polymers of ethylene, in primary forms	0.6485	0.0572	0.68%
Printing machinery used for printing by means of plates, cylinders and other printing components; other printers, copying machines and facsimile machines, whether or not combined; parts and accessories	0.5986	0.0827	2.92%
Special Classification Provisions	0.5870	0.1279	5.08%
Mixtures of odoriferous substances and mixtures (including alcoholic solutions) with a basis of one or more of these substances, of a kind used as raw materials in industry; other preparations based on odoriferous substances, of a kind used for the manufacture of beverages	0.5836	0.1004	0.48%
Turbojets, turbopropellers and other gas turbines	0.5814	0.0578	0.51%
Portable electric lamps designed to function by their own source of energy	0.5790	0.1070	0.41%

Subchapter	Elasticity	TMAC 2010-2022	Participation in M
Harvesting or threshing machinery, including straw or fodder balers; grass or hay mowers; machines for cleaning, sorting or grading eggs, fruit or other agricultural produce	0.5751	0.0590	0.73%
Electric motors and generators	0.5639	0.0939	0.72%
Taps, cocks, valves and similar appliances for pipes, boiler shells, tanks, vats or the like, including pressure-reducing valves and thermostatically controlled valves	0.5559	0.1178	0.51%
Flat-rolled products of iron or nonalloy steel, of a width of less than 600 mm (23.6 in.), not clad, plated or coated	0.5548	0.0973	0.52%
Aluminum plates, sheets and strip, of a thickness exceeding 0.2 mm (0.0079 in.)	0.5378	0.1189	0.78%
Electric generating sets and rotary converters	0.4900	0.1274	0.72%
Compression-ignition internal combustion piston engines (diesel or semi-diesel engines)	0.4755	0.0923	1.40%
Petroleum gases and other gaseous hydrocarbons	0.4483	0.1332	3.64%
Petroleum coke, petroleum bitumen and other residues of petroleum oils or of oils obtained from bituminous minerals	0.4197	0.0725	8.78%
Sound recording or reproducing apparatus	0.3877	0.0922	0.80%
Other articles of aluminum	0.3660	0.0722	0.37%
Hydrometers and similar floating instruments, thermometers, pyrometers, barometers, hygrometers and psychrometers, recording or not, and any combination of these instruments	0.3274	0.0329	0.94%
Flat-rolled products of iron or nonalloy steel, of a width of 600 mm (23.6 in.) or more, cold-rolled (cold-reduced), not clad, plated or coated	0.0894	0.3481	0.87%

Source: prepared by the authors.

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