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Contaduría y Administración
Accounting & Management

Contaduría y Administración 67 (4), 2022, 1-24

Government revenues and business cycles in Mexico: An analysis of structural change

Ingresos públicos y ciclos económicos en México: un análisis de cambio estructural

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Received February 18, 2020; accepted September 5, 2020
Available online September 27, 2023

Abstract

The aim of this paper is to analyze the relationship between public revenues and the business cycle (product-elasticity) in Mexico over the period 1980.I-2018.III, allowing for possible structural changes. To do so, bivariate econometric models of several public revenues on the business cycle indicator are estimated. Our results suggest the existence of changes in those relationships that can be associated to modifications in the tax policy and variations in the international price and the exportation platform of oil. A major implication of these findings is that total public revenues are highly dependent on income and consumption taxes, something that should be taken into account in a possible fiscal reform along with the estimated magnitude of the relationships for the most recent period.

JEL Code: E23, E32, E62, C20
Keywords: business cycles; production; taxes; oil revenues; structural change

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Peer review under the responsibility of Universidad Nacional Autónoma de México.

http://dx.doi.org/10.22201/fca.24488410e.2022.2850

http://dx.doi.org/10.22201/fca.24488410e.2022.2850

Resumen

El objetivo de este documento es analizar la relación entre los ingresos públicos y los ciclos económicos (elasticidad-producto) en México durante el periodo 1980.I-2018.III tomando en cuenta la posibilidad de cambios estructurales. Para ello, se estiman modelos econométricos bivariados en los que los diferentes tipos de ingresos públicos dependen del indicador del ciclo. Los resultados muestran que efectivamente hay cambios estructurales en las relaciones estimadas que se pueden identificar con modificaciones en la política tributaria y con las variaciones en los precios y la plataforma de exportación de petróleo. Una implicación importante de nuestros resultados es que los ingresos públicos totales son altamente dependientes de los impuestos al ingreso y al consumo, algo que debe considerarse en una posible reforma fiscal en combinación con la magnitud de las relaciones estimadas para el periodo reciente.

Código JEL: E23, E32, E62, C20
Palabras clave: ciclos económicos; producción; impuestos; ingresos petroleros; cambio estructural

Introduction

The dynamics and structure of public revenues in Mexico have long been the subject of concern among scholars and public officials because their limitations have been a major obstacle to macroeconomic stabilization and to the overcoming lags in infrastructure and social development in the country. Indeed, some of the most pressing structural problems are the slow growth of the collection of several of the most important tax items, such as income tax (ISR) (Spanish: Impuesto sobre la Renta) and value-added tax (VAT); the high dependence on oil revenues during different periods, and the high tax evasion and avoidance, among others (Chávez, 2001; Martner, 2006; Ramírez, 2013; Tello, 2015). These and other restrictions have resulted in low levels of tax collection compared to those of the Organization for Economic Cooperation and Development (OECD) countries and even those of other Latin American countries of similar levels of development (OECD, 2019; Robles & Huesca, 2013).

Among the different studies that analyze the dynamics of tax collection in Mexico, those (not many) that link it to productive activity stand out, assuming that the former depends on the latter, as postulated in the international literature (e. g. Sancak et al., 2010; Martner (2006), Daude et al. (2011) and Machado and Zuloeta (2012).[1] In particular, one area of research has analyzed the co-movement (correlation) between tax collection and the business cycle. At the same time, another has focused on estimating the output elasticity of different types of taxes. In the first case, only a few papers analyze the co-movement between aggregate fiscal variables, such as total public income, and various measures of the business cycle (Agénor et al., 2000; Mejía, 2003; Martner, 2006). In general, both show that public

[1]Given the purpose of this paper, explained below, the literature review is limited to studies that analyze the relation between government revenues and some measure of productive activity, even though some may depend on other variables, such as private consumption or oil price. An analysis of these possibilities is left for future studies.

income is acyclical from the early 1980s to the late 1990s, with very low correlations, which can be explained by the high volatility of the variables involved in a period of frequent and deep economic crises, with significant changes in tax policy and key variables, such as oil prices.

For this paper, the study by Burnside and Meshcheryacova (2005) and Cardoza (2017), who perform a more detailed analysis of public revenues, separating them into Federal Tax Revenues, Federal Non-Tax Revenues, and Revenues from Public Companies, stands out. Again, they report modest positive correlations between the cycle and the cyclical components of the different types of taxes and negative correlations with oil revenues.

Regarding the second branch, the studies are based on different types of bivariate regressions where tax collection is explained by productive activity. For Mexico, authors such as Cárdenas et al. (2017) and Fonseca and Ventosa (2011) find that ISR and VAT revenue are elastic in the long run relative to output by estimating cointegration models with structural change. Similarly, CEFP (2009) argues, based on the estimation of error correction models, that the same is true in the short run.[2] On the contrary, authors such as Martner (2006), Daude et al. (2011), and Machado and Zuloeta (2012) argue, based on different estimation methods, that short-run elasticities are lower than long-run elasticities and that they differ between income taxes, corporate taxes, and consumption taxes. Moreover, the latter argue that elasticities are only statistically significant in recessionary phases.[3]

As can be seen, these studies have analyzed the dynamics of aggregate collection of the most important taxes but not of most government revenues. Moreover, only the possibility of structural changes in the relation between taxes and production in the long run and somewhat between the phases of the economic cycle has been analyzed, but not over time in the short run. This is a significant omission since there have been significant changes in tax policy and the determinants of important additional revenues over the last four decades.[4] Therefore, this paper aims to analyze the relation (which can be interpreted as output-elasticity) of different types of government revenues with the business cycle in Mexico from 1980.I-2018.III, highlighting statistically determined structural changes in this relation that may have occurred over time. The aim is to contribute to defining a general basis for discussing tax reform in

[2]Cardoza (2017) and Martner (2006) use similar methods, but without structural change, for several Latin American countries and find that the response of taxes to output is elastic in the long run, with exceptions including Mexico, but not in the short run.
[3]The reader is referred to Cardoza (2017), Machado and Zuloeta (2012), Fricke and Süssmuth (2011), and Vladkova-Hollar and Zettelmeyer (2008) for a broader review on the literature on tax output elasticity.
[4]In terms of public finance, it is interesting to note that the study of changing relations over time has recently attracted the attention of researchers. For example, Ramírez and López (2019) use a model with Markovian regime-switching and dynamic correlations to study the relation between public spending and the business cycle in Mexico, while Mejía and Sánchez (2019) analyze the existence of structural changes with the methodology of Bai and Perron (1998), to determine whether the relation between government spending and some of its components and the business cycle has been stable in the central Mexican states.

http://dx.doi.org/10.22201/fca.24488410e.2022.2850

Mexico.

The remainder of this document consists of four sections. The first provides an overview of the problems of government revenues in Mexico, highlighting the low levels of tax collection and the high dependence on oil revenues. The second section presents the methodology followed in this paper to measure the possibly changing output elasticity of the different types of public revenues. In contrast, the third section presents and states the results obtained. Finally, the main conclusions are drawn.

Government revenues in Mexico

After the structural problems inherited from the import substitution model and the expansionary policies adopted in the late 1970s and early 1980s led to the debt crisis of 1982, the Mexican government adopted a fiscal policy that adhered to the principles of economic orthodoxy. First, restrictive measures were followed to stabilize the economy based on a diagnosis that inflation and the current account deficit resulted from excess demand (Ros, 1987; Cárdenas, 1996; Chávez, 2001; Ibarra, 2019). Subsequently, a prudential policy has been adopted in which efforts have been made to keep the fiscal deficit at low or zero levels and reduce government indebtedness (Esquivel, 2010; Casar, 2020).

Although one of the most important achievements of the different federal administrations of the last four decades has been macroeconomic stabilization, fiscal policy has faced structural restrictions on the government revenue side. Given this situation, the objectives of reducing the fiscal deficit and maintaining low levels of public indebtedness have been achieved mainly through successive cuts in government spending, especially investment (Figueroa, 2004; Eustáquio & Vaz, 2011; Casar, 2020).

Indeed, Mexico has faced serious limitations in increasing its tax collection due to different factors, including the absence of a comprehensive tax reform, a narrow taxpayer base, and a reduced group of taxes. As a result, collection in Mexico has been very low compared to other OECD countries. For example, consumption tax collection is between 12 and 15% of GDP in countries such as Sweden, Denmark, Finland, and Norway, while in Mexico, it has reached an average of 5%. Similarly, income and profits tax collection ranges between 16 and 28% in the same countries, while in Mexico, it is around 6% (OECD, 2019). An additional problem for Mexico is its relatively high dependence on oil revenues, which, in turn, vary with the international oil price and the size of the export platform (Martner, 2006; Villagómez & Navarro, 2010; Tello, 2014).

Figure 1 shows the shares of the main components of government revenues, which makes it possible to appreciate their relative importance in the total. In particular, it can be seen that the weight of non-oil revenues behaves like that of tax revenues, their most important component. In fact, according to figures from the SHCP (Spanish: Secretaría de Hacienda y Crédito Público) (2019), the former accounts for about 69% of the total, while the latter reaches 43% on average. Figure 1 shows lower shares of both items during periods of low economic activity (most of the 1980s and the 1995 recession) and for several years of the first decade of this century (when oil prices rose significantly), and vice versa. The recent rebound (when non-oil and tax revenues reached 80% and 60% of the total, respectively) stands out, associated with the drop in the international price and proven national oil reserves, the 2013 tax reform that stimulated the formalization of informal activities, and the increased taxation that has managed to reduce the profits of interconnected business groups (Mejía & Ochoa, 2018; Unda, 2015; Ibarra, 2019).

On the other hand, the share of oil revenues in total revenues has shown a pattern contrary to that of the previous items due to the abovementioned factors. Particularly noteworthy are its high levels in the 1980s, when oil exports accounted for more than 70% of the total, and when the price of oil rose to USD 100 per barrel between 2005 and 2012. In both episodes, the share of this category was around 40% of total government revenues. In contrast, oil revenues have had less weight when production and tax collection grow (see also Tello, 2014, and Ibarra, 2019).

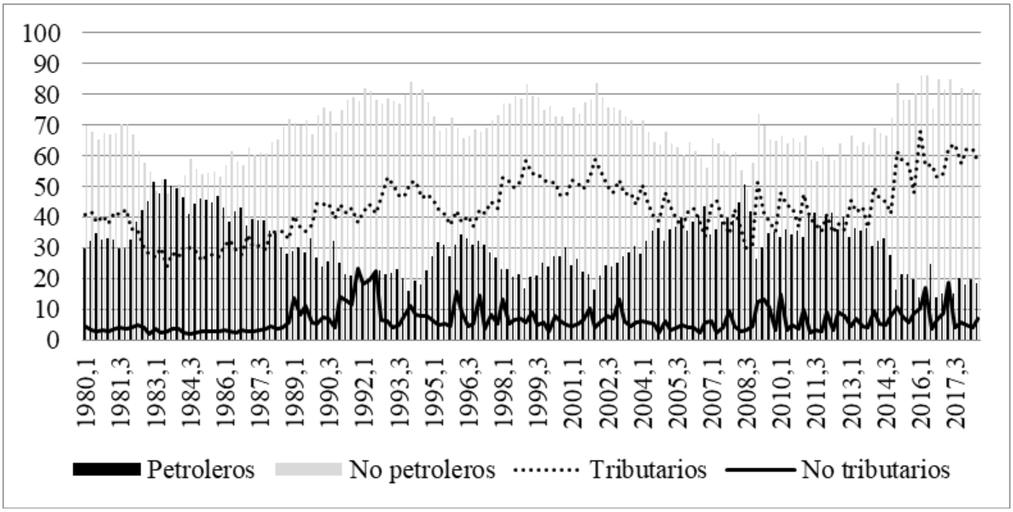

Figure 1. Percentage structure of public revenues in Mexico, 1980.I-2018.3
Source: created by the authors with data from SHCP (2019)

Finally, non-oil and non-tax revenues (products, profits, and rights) have had limited participation throughout the period due to the slimming of the governmental apparatus that began in the early 1980s (see Figure 1).

In general, figures from the Secretaría y Hacienda y Crédito Público (SHCP, 2019) indicate that oil revenues had a relatively high share of total revenues, averaging around 30% during the period 1980-

http://dx.doi.org/10.22201/fca.24488410e.2022.2850

2018, reflecting the dependence that public finances have had on the exploitation of this resource. The almost 70% of non-oil revenues are divided into those corresponding to the federal government (49.4%), mainly taxes, and those of public agencies and companies (19.7%), where a broad spectrum of revenues of little individual importance are agglutinated. Tax revenues, as expected, are one of the most important items, with a 42.6% share of the total, with income tax and VAT accounting for 20.6% and 13.9%, respectively. The Special Tax on Products and Services (STPS), which has become increasingly important in recent years, accounts for 5.3% of the total, with 3% corresponding to gasoline and diesel.

Average annual growth rates and their volatility, measured by standard deviation, have been heterogeneous. Regarding only some of the most important items, the high growth rates of tax revenues (3.6%) and income tax and VAT (3.7% and 4.0%, respectively) are worth noting. Likewise, the average growth of Non-Tax Revenues (4.5%) stands out as a result of the high rate of the category Profits "Aprovechamientos" (8.0%). In contrast, the low average rate of Oil Revenues (1.2%) is striking. Overall, public revenues increased at an annual average rate of 2.6% over the whole period.

Volatility, in general, is high for several types of income. These include, for example, oil revenues and their different components, as well as the total STPS and the STPS on gasoline and diesel. Likewise, the high volatility of non-petroleum revenues, especially in the items of Income and Products, is also noteworthy. In contrast, except for the STPS above, Tax Revenues have a volatility of approximately half that of the previously mentioned items.

Nevertheless, although illustrative, these average statistics may hide differentiated growth patterns of the variables analyzed over time and changes in their relation to other variables, such as productive activity. The reasons for this could be many, but of course, changes in tax policy or oil market conditions stand out, as mentioned above.

For example, the highest ISR for individuals decreased to 32% in 2005 and 28% in 2014, while for companies in the simplified regime, it was set at 21% in 2014 (Castañeda, 2014; Sobarzo, 2007). At the end of the seventies, the 4% tax on commercial income was replaced by a general rate of 10% Value Added Tax (VAT).[5] Subsequently, during the six-year term of Miguel de la Madrid Hurtado, the rate was set at 15% and two special regimes were created, one with a 6% rate for food and medicines and the other with a 20% rate for luxury goods (Castañeda, 2014). The changes continued in the early nineties (during the government of Carlos Salinas de Gortari) when a rate of 10% (including luxury goods) was adopted, and a zero rate was established for medicines and foodstuffs, in force to date. The situation was partially reversed due to the need to increase tax collection to face the 1995 crisis when the tax rate was raised to 15%, and the Small Taxpayers Regime (REPECOS) (Spanish: Régimen de Pequeños Contribuyentes) was

[5]A differential rate of 6% was applied for the states bordering the United States.

created. These rates prevailed until 2009, when the VAT was raised to 16%, with a rate of 11% for the northern border states. During Enrique Peña Nieto's six-year term, the rate was homogenized for the entire country at 16% (Castañeda, 2014; Ramírez, 2013).

On the other hand, the Excise Tax on Products and Services (IESPS) (Spanish: Impuesto Especial Sobre Productos y Servicios) has grown the least and contributed the least to tax revenues. After the 1995 crisis, taxes on some products, such as bottled water, soft drinks and concentrates, telephone services, and individual insurance, were eliminated. In return, tax rates for wines, spirits, and beer were increased, a measure maintained until the end of the period analyzed in this document (Castañeda, 2014).

Given these transformations, the possibility that tax collection has changed over time is evident. The following sections estimate the (possibly changing) relation that government revenues have had with productive activity, measured in different ways.

Methodology

The methodology for estimating the relation between the different types of government revenues and productive activity consists of two stages. In the first, a stationary transformation of the different variables is obtained. In the second, the relation between the former and the latter is estimated, enabling the possibility of structural changes, where the estimated slope coefficients are interpreted as output-product elasticities of government revenues.

Obtaining stationary transformations of the different variables is based on the two most popular cycle approaches in the empirical literature. On the one hand, the definition of the cycle as "the movements around the trend of the gross national product" and the analysis of "the common movements of the deviations, regarding a trend, of the different aggregate time series," as stated by Lucas (1977: 3), is emphasized. Accordingly, fluctuations could be above and below the underlying output trend even if the economy grows steadily. This is why this approach is known as a growth cycle approach.[6]

Conventionally, based on empirical methodology popularized by Kydland and Prescott (1990), the Hodrick and Prescott (1998) filter, denoted HP, is used to decompose the time series into a trend and a stationary component (cycle indicator). For this purpose, it is assumed that a seasonally adjusted time series z_t is made up of three stochastic components:

$$z_t = \tau_t + c_t + \varepsilon_t \tag{1}$$

[6]Several studies use this methodology to analyze different aspects of Mexico's cycles, such as Agénor *et al.* (2000), Torres (2000), Mejía (2003), and Cuadra (2008), among others.

where τ_t is the trend component, c_t the cyclical stationary component, and ε_t the irregular but also stationary component, for t = 1, 2, ..., T. Essentially, the HP is a two-sided linear filter to estimate the smoothed series τ_t from z_t by minimizing the variance of the latter around the former and penalizing the acceleration of the trend growth rate. The trend calculation involves a penalty parameter λ, which controls its smoothness (smoothing parameter): large values of λ generate smoother trends and vice versa.[7] Then, from expression (1), the HP filter obtains a cyclic indicator defined as

$$c' = c_t + \varepsilon_t = y_t - \tau_t \tag{2}$$

where it can be seen that the cycle indicator includes the noise term, which adds more volatility.[8]

On the other hand, based on Burns and Mitchell's (1946) view of the classical cycle, in which the cycle is recognized from the ups and downs in the absolute level of the variables analyzed, their growth rates (GR) are also used, which not only eliminate the underlying trend of the series but could be associated with the succession of the expansion and recession phases of the cycle during which they would take positive and negative values, respectively, as argued by Pérez et al. (2007).[9] Moreover, the growth rate is a transformation commonly used in economic analysis.

These two trend elimination methods provide complementary, but not identical, results: on the one hand, those corresponding to the frequency of the (growth) cycle, and, on the other hand, those associated with the conventional measure of growth of the variables that can be linked to the classical cycle approach.

In the second stage, the Bai and Perron (1998) test is used to estimate relations with possible and multiple structural changes to determine whether there have been changes in the relation between public revenues and productive activity. The methodology is based on linear regression models estimated sequentially through minimization of the sum of squared residuals.[10] The general model without structural changes for two stationary variables x_t and y_t can be defined as:

$$y = \alpha + \beta x_t + \varepsilon_t \tag{3}$$

[7]For quarterly series, a value of λ= 1600 is used.

[8]As will be seen below, it appears that the noise term plays an important role in the determination of structural changes, since the results obtained with the HP filter are very similar to those corresponding to the annualized growth rates.

[9]Strictly speaking, a classical approach is not used, as it would require precisely the identification of the corresponding phases of expansion and recession. Nevertheless, the use of growth rates, in addition to approximating them from their positive and negative values, allows parametric methods to characterize the relation between the variables of interest alternatively.

[10]Notably, Bai and Perron (1998) argue that their methodology is valid even in the presence of general forms of autocorrelation and heteroscedasticity, as well as lagged dependent variables, regressors with trend, and different distributions of the errors in the different estimated regimes.

where y_t is the observed dependent variable (in this case, some government revenue), x_t the explanatory variable (an indicator of the business cycle), and ε_t the disturbance term following a white noise process; α and β denote the intercept and the coefficient-slope with constant values in the sample.[11]

On the other hand, a model that considers m structural changes (and, therefore, $m + 1$ regimes) can be formulated as follows

$$y_t = \sum_{i=1}^{m+1} \alpha_i D_{it} + \sum_{i=1}^{m+1} \beta_i D_{it} x_t + \varepsilon_t \tag{4}$$

for the regimes $i = 1, \ldots, m + 1$, where the indices $(T_1, \ldots, T_m)$ represent the unknown break dates.[12] D_{it} is a dichotomous variable that takes the values of 1 for the sample segment $T_{i-1} < t < T_i$ and zero for any other case $(i = 1, \ldots, m + 1)$. The objective is to estimate the unknown coefficients α_i and β_i along with the dates of structural change T_i when one has T observations of x_t and y_t.

A sequential procedure is followed to determine the dates of the multiple structural changes. That of the first, denoted $\widehat{T}_1$, corresponds to that which minimizes the sum of squared residuals in a model for the whole sample incorporating a dichotomous variable D_{1t}, which takes values equal to 1 in the segment $T_0 < t < T_1$ and zero otherwise, and the parameters $\widehat{\alpha}_1$ and $\widehat{\beta}_1$ and $\widehat{\alpha}_2$ and $\widehat{\beta}_2$ of the first and second regimes into which the whole period is divided.[13] It should be noted that successive regressions are estimated in which each date of the estimation period serves as a candidate of the structural change. To this end, $\widehat{T}_1$ corresponds to the one for which the lowest sum of squared residuals of all those obtained in this way is obtained.

In the next step, the whole sample is divided into two segments $[1, \widehat{T}_1]$ and $[\widehat{T}_1, T_{m+1}]$ and the same procedure is followed for each of them in order to estimate a new structural change point, and so on.

In general, since the estimation method considered is based on the ordinary least squares principle, the estimates of α_i and β_i corresponding to each m-th partition $(T_1, \ldots, T_m)$, denoted $\{T_i\}$, are represented as $\widehat{\alpha}(\{T_i\})$ and $\widehat{\beta}(\{T_i\})$. Substituting these in the objective function and expressing the result

[11]The relation between the correlation coefficient (r) between two random variables x and y and the slope coefficient of the regression between them (b) can be expressed as $r = b\frac{S_x}{S_y}$, where S_x and S_y denote the corresponding standard deviations. In this way, it is possible to move from regression analysis to co-movement analysis, which is more common in the study of economic cycles, and assess their equivalence.
[12]By convention, $T_0 = 0$ and $T_{m+1} = T$ denote the beginning and end of the sample.
[13]Conventionally, 15% of the observations at the beginning and at the end of the sample are excluded (trimming percentage) to have the minimum degrees of freedom to estimate the parameters of the first and last regimes, so that T_1 and T_m will be in the interval [0.15, 0.85] of the sample.

of the sum of the squared residuals as $S_T(T_1, \ldots, T_m)$ and the estimated breakpoints as $(\hat{T}_1, \ldots, \hat{T}_m)$, it is found that

$$(\hat{T}_1, \ldots, \hat{T}_m) = \mathrm{argmin}_{T_1,\ldots,T_m} S_T(T_1, \ldots, T_m) \tag{5}$$

where the minimization is taken over all partitions $(T_1, \ldots, T_m)$, such that $T_i - T_{i-1} \geq q$. Thus, the estimators of the break dates are those that globally minimize the objective function, while the estimated parameters of the regression are associated with the estimated least squares of the m-th partition obtained $\{T_i\}$, i.e. $\hat{\alpha}_i = \hat{\alpha}(\{\hat{T}_i\})$ and $\hat{\beta}_i = \hat{\beta}(\{\hat{T}_i\})$.

Bai and Perron (1998) propose a statistical test to evaluate the null hypothesis of the existence of l breaks versus the alternative of $l + 1$ breaks; the test determines the number and the date of structural changes. The test statistic is likelihood ratio type and follows an F distribution. To reject the null hypothesis, the total minimum value of the sum of squared residuals (over all segments in which an additional break is included) must be sufficiently smaller than the sum of squared residuals of the model with l breaks, so the test statistic is defined as

$$\mathrm{supLR}_T(l + 1|l) = \frac{S_T(\hat{T}_1, \ldots, \hat{T}_l) - S_T(\hat{T}_1, \ldots, \hat{T}_{l+1})}{S_T(\hat{T}_1, \ldots, \hat{T}_{l+1})T} \tag{6}$$

In general, this statistic measures the statistical difference between the optimal sum of squared errors of the model with l structural changes and the optimal of the model with $l + 1$ changes. Critical values are calculated and reported by Bai and Perron (2003).

Once the number and timing of structural changes have been identified, the relation between the variables for each regime can be estimated from Model (4). Each of the estimated coefficients could be viewed as the output elasticities of the different types of income in the different regimes: as percentage changes when using growth rates and as percentage changes over the trend of the explained variable when using the HP filter.

Results

The analysis of the relation (output elasticity) between the different types of public revenues and productive activity, measured through the Gross Domestic Product (GDP), is based on the methodology presented in the previous section. Seasonally adjusted and measured in real terms, quarterly series are used for the period 1980.I-2018.III. For illustrative purposes, Figure 2 shows the log, trend, and cyclical component estimated with the HP filter of the GDP series.[14] Noteworthy are the falls below the trend that can be linked to the recessions of 1982-1983, 1985-1986, 1995, 2001-2003, and 2009, as well as the upturns above the trend associated with the corresponding expansions.

Similarly, for comparative purposes, Figure 3 shows the cyclical components obtained with the HP filter of GDP and total public revenues (TR), Oil (O), and Non-oil (NO). The greater volatility of O and the notable differences in its behavior concerning that of GDP, which contrasts with that of TR and NO, are striking. Nevertheless, these items also show different patterns at different times during the period analyzed.

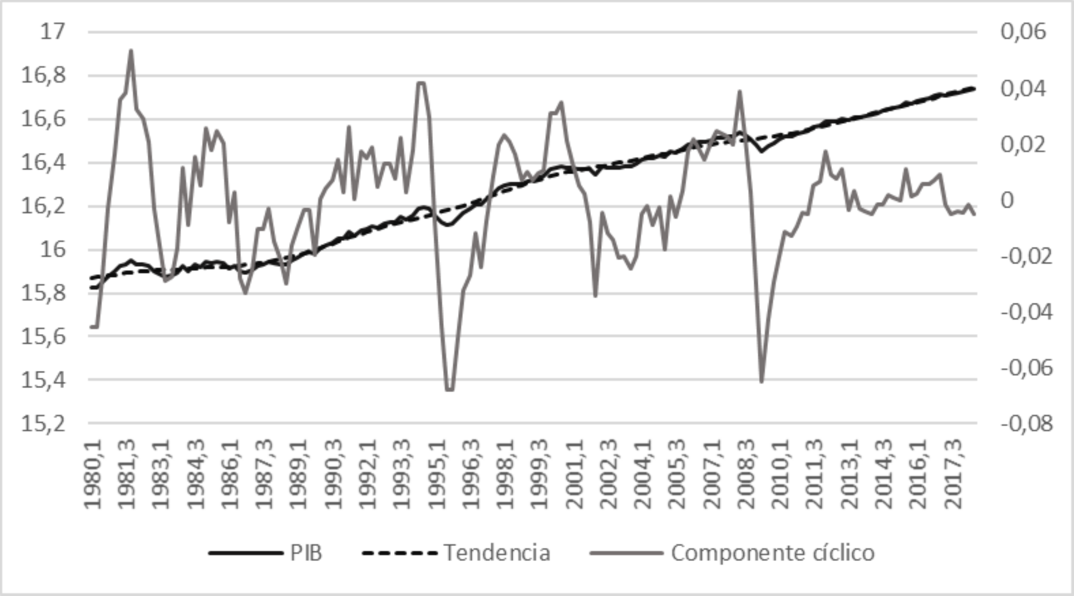

Figure 2. Logarithms, trend, and cyclical component of GDP, 1980.I-2018.III (HP Filter)
Source: created by the authors with data from INEGI (2019)

[14]Unit root tests were performed to confirm the stationarity of the series used in the analysis, even though the HP filter generates stationary series by construction. Indeed, the corresponding cyclical components are stationary according to the generalized least squares-adjusted augmented Dickey-Fuller test (GLS-ADF) and the Phillips-Perron test (valid in the presence of heteroscedasticity and time dependence), except in two different cases for each of them. In turn, all annualized growth rates are stationary, at least at 10% significance, according to the PP test, and 9 are not according to the GLS-ADF. These results are available upon request.

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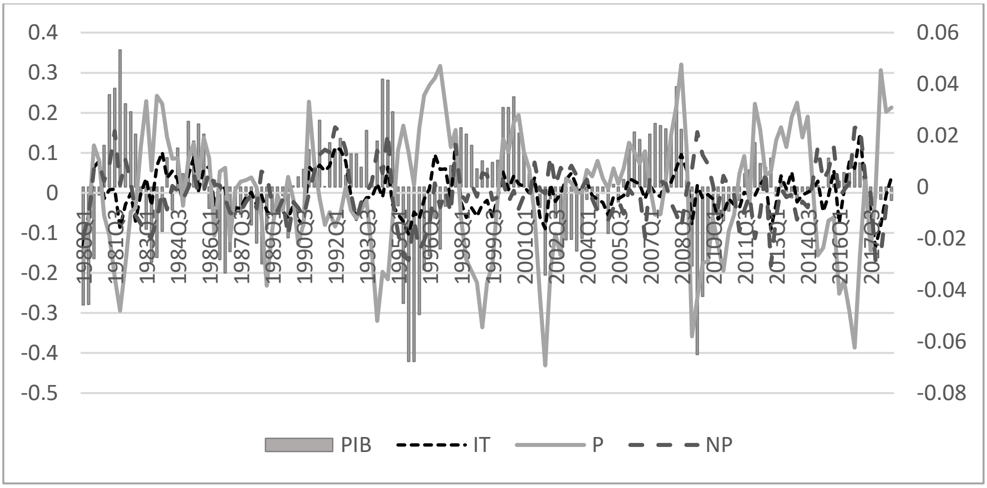

Figure 3. GDP and total income, oil income, and non-oil income of Mexico, 1980-2018 Cyclical components obtained with the HP filter
Source: created by the authors with data from INEGI (2019)

Figure 4 shows the annualized growth rates of tax revenues (TR) and the main taxes, VAT and ISR, as well as GDP. Also noteworthy is the greater volatility in the growth of these revenues, although in general it can be seen that their dynamics are more similar to those of GDP. Tax collection, nevertheless, also shows additional fluctuations that could be attributed to other causes.

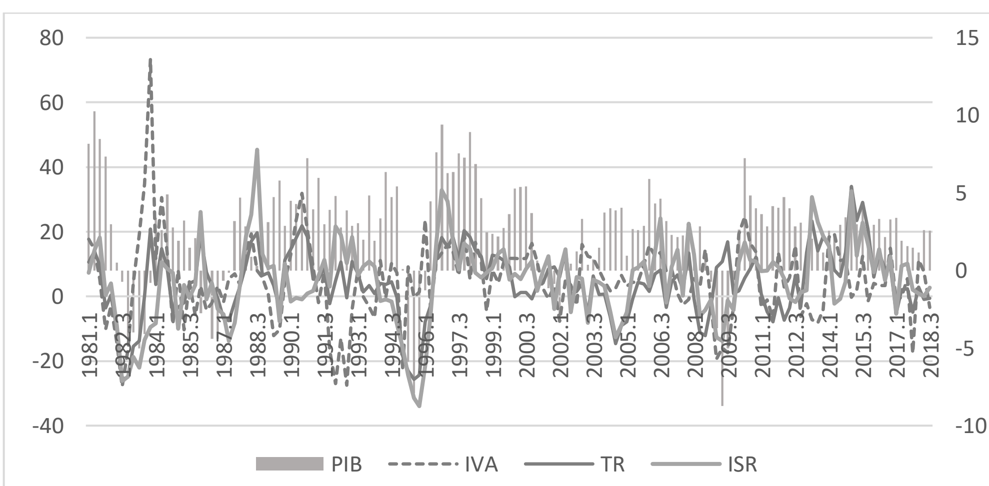

Figure 4. Mexico's GDP and total tax, income tax, and VAT revenues, 1980-2018 Annualized growth rates
Source: created by the authors with data from INEGI (2019)

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Estimates of the relations between public revenues and GDP, obtained with the methodology of Bai and Perron (1998), are organized in Tables 1 to 3.[15] As explained in the previous section, the number of regimes is equal to the number of structural changes plus 1. The results differ among the different types of income as well as the trend elimination methods. Nevertheless, it is worth noting that the number of structural and, therefore, regime changes is similar in several cases, regardless of the trend elimination method.[16]

Interestingly, even when there have been changes in tax policy throughout the period under study, the relations between some items of public revenues and productive activity have undergone insignificant structural changes. Particularly, as seen in Table 1, the estimates for total income are constant across the sample, positive, significant, and approximately the same value as the two trend elimination methods, suggesting that they are pro-cyclical but inelastic, which is consistent with the results of Martner (2006), Daude et al. (2011), and Machado and Zuloeta (2012). In contrast, its main components, Oil (O) and Non-oil (NO) revenues, show at least one structural change.[17]

Table 1
Estimates of the different regimes of Mexico's government revenue-to-GDP relation, 1980-2018 (Total, Oil, and Non-oil Revenues)

Government Revenues	Annualized growth rates			Hodrick-Prescott filter		
	Regimes	Intercept	Slope	Regimes	Intercept	Slope
Total revenues (TR)	1981.1-2018.3	1.615 (0.228)	0.568 (0.077)	1980.1-2018.3	0.000 (1.000)	0.657 (0.006)
1. Oil (O)	1981.1-1993.3	8.26 (0.217)	-2.508 (0.069)	1980.1-1999.4	-0.004 (0.858)	-2.565 (0.001)
	1994.4-2012.2	1.670 (0.690)	5.716 (0.000)	2000.1-2012.4	0.002 (0.884)	5.053 (0.000)
	2012.3-2018.3	15.639 (0.200)	-8.937 (0.096)	2013.1-2018.3	0.010 (0.776)	-26.810 (0.000)
1.1 PEMEX*	1981.1-2018.3	4.234 (0.058)	-0.844 (0.038)	1980.1-2018.3	0.000 (1.000)	-0.643 (0.118)
1.2 Federal Government (FG)	1981.1-1999.3	14.482 (0.145)	-3.853 (0.090)	1980.1-1999.3	-0.013 (0.723)	-3.608 (0.001)
	1999.4-	0.388	21.958	1999.4-	0.014	8.833

15 For reasons of space, neither the test statistics on the number of breaks nor the model specification tests are presented. Nevertheless, this information is available upon request.

16 When necessary, the Newey-West correction has been used to obtain robust estimates of the standard errors in autocorrelation and heteroscedasticity.

17 It should be mentioned that the role of possible structural changes in the stationarity of individual series has been explored with the Lee and Strazicich (2003) test in determining changes in the relations between the business cycle and public revenues. In general, there is no correspondence between the regimes identified with both methodologies, so it can be assumed that changes in the stationarity of the series may affect the relations with the cycle but do not necessarily condition them in all cases. For example, there are series with structural changes in their stationarity (such as ISR and GDP) but with stable relations with the cycle throughout the sample. The test results of Lee and Strazicich (2003) are available upon request.

http://dx.doi.org/10.22201/fca.24488410e.2022.2850

	2005.2	(0.976)	(0.000)	2012.4	(0.744)	(0.000)
	2005.3-	-7.933	5.270	2013.1-	0.005	-30.368
	2018.3	(0.238)	(0.000)	2018.3	(0.921)	(0.001)
				1980.1-	-0.003	-0.879
				1999.4	(0.822)	(0.091)
1.2.1 Hydrocarbon Rights (HR)*				2000.1-	0.001	4.660
	1981.1-	0.061	0.646	2012.4	(0.929)	(0.000)
	2018.3	(0.987)	(0.503)	2013.1-	0.013	-33.327
				2018.3	(0.834)	(0.000)
	1981.1-	-0.807	1.419	1980.1-	-0.001	1.765
	2001.1	(0.691)	(0.000)	2000.1	(0.877)	(0.000)
2. Non-Oil (NO)	2001.2-	6.245	-1.838	2000.2-	-0.002	-1.409
	2013.1	(0.000)	(0.000)	2012.4	(0.799)	(0.001)
	2013.2-	-21.198	11.599	2013.1-	0.004	11.512
	2018.3	(0.200)	(0.035)	2018.3	(0.613)	(0.000)
	1981.1-	-0207	1.523	1980.1-	-0.001	2.205
	2008.4	(0.928)	(0.000)	2000.1	(0.907)	(0.000)
2.1 Non-Oil Federal Government (NOFG)				2000.2-	-0.003	-2.133
				2012.4	(0.787)	(0.002)
	2009.1-			2013.1-	0.007	13.375
	2018.3	14.372	-2.792	2018.3	(0.535)	(0.000)
		(0.000)	(0.000)			

* According to the Box-Cox transformation, 100 000 was added to these variables to avoid negative values and obtain logarithms before applying the HP filter.
Source: created by the authors with data from SHCP (2019)

For the case of oil revenues, the estimation indicates two structural changes and three regimes with the two trend elimination methods. Estimates with the HP filter are very suggestive because they are consistent with major changes in the oil market. The first regime covers the first two decades of the sample when the national economy experienced wide fluctuations and underwent a series of structural reforms. Particularly, although the recessions of 1982-1983 and 1986 were associated with the fall in oil prices, during the rest of that first sub-period, the movements of both variables showed an uneven behavior, resulting in a negative and significant coefficient (at 10%).[18] The second regime corresponds to the rebound in the demand for primary products worldwide, including oil, which led to an unprecedented rise in the price of this product until around 2013. The behavior of the Mexican economy and oil price movements were synchronized with the recovery phases of the international economy and its downturn during the Great Recession, so oil revenues show a positive and significant relation with the cycle indicator. Finally, the last period is associated with the fall and instability in the international oil price and the reduction of the national oil export platform (Unda, 2015; Mejía & Ochoa, 2018; Casar, 2020). Therefore, the estimated slope coefficient is negative and significant (as when working with growth rates).

[18]For a similar period, Burnside and Meshcheryacova (2005) obtained qualitatively similar results.

The relations of the components of the federal government's oil revenues (FG) and its hydrocarbon rights (HD) with the cycle are qualitatively similar regarding the identified regimes and the signs of the estimated coefficients to those obtained when the HP filter is used.[19] On the other hand, although not always significant, the econometric estimation suggests a negative relation throughout the period between PEMEX's revenues (PX) and the economic cycle.

For NO, the estimates with growth rates and the HP filter are consistent and have some important fiscal policy modifications. In these cases, two structural changes are identified that lead to three different regimes that coincide with those found in the case of non-oil revenues of the Federal Government (NOFG). The first regime also covers approximately the first two decades of the period analyzed, when these revenues are pro-cyclical and elastic, consistent with the evidence reported by Belinga et al. (2014). The second regime goes up to 2012 and includes the period when oil prices were generally high, which may have led to less stringent fiscal measures by the federal government. As a result, NO and NOFG are counter-cyclical, with coefficients of different magnitude but greater than 1, and statistically significant. Finally, the third regime coincides with the fall in oil revenues and the 2013 tax reform, which has had significant effects, as the estimated coefficient not only becomes positive and meaningful, but its magnitude grows notably to values above 10.

These results are consistent with those obtained when the HP filter is applied to tax revenues (TR), although the first regime is divided into two, as shown in Table 2. Thus, between 1980.I and 1992.I and between 1992.II and 1999.IV, this variable is pro-cyclical, elastic, and statistically significant, with a higher coefficient in the second sub-period. The increase in the pending coefficient could be associated with the generalization of VAT to a 10% rate in 1990 (even if that meant a reduction in the rate itself). For the above reasons, in the period 2000.I-2012.IV tax revenues become counter-cyclical, with a coefficient of less than 1 and significant at 10%. Again, the same revenues resume their pro-cyclical, significant, and highly elastic character as of 2013.

Differences in estimates for specific taxes suggest that tax adjustments, especially those in 2013, may have had an aggregate effect. Specifically, the impact of the business cycle on ISR revenues is constant across the sample and statistically significant, so they can be classified as pro-cyclical and elastic, which is similar to what has been previously reported in the national (Cárdenas et al., 2017; CEFP, 2009) and international (Dudline & Jalles, 2007; Belinga et al., 2015) literature and to the estimates in this paper for import taxes (IM). On the other hand, VAT revenues consistently show a structural change between 1996 and 1997 when using the annualized growth rate or the HP filter. This may have resulted from an increase in VAT to 15% as part of orthodox policies to consolidate public finances and face the 1995

[19]In the case of FG, the regimes identified when using the growth rates also coincide, although the sign of the coefficient of the third regime is not negative, but only lower than that of the second regime.

crisis. Indeed, until the years following the 1995 recession, VAT collection did not adjust to the cyclical pattern of the national economy, as its coefficients were not statistically significant. Nevertheless, from those years onwards, once the harmful effects of the fall in productive activity on tax collection faded, VAT revenues became positive, significant, and elastic, which is in line with the estimates of Cárdenas et al. (2017) and CEFP (2009).

Table 2
Estimates of the different regimes of Mexico's public revenue-to-GDP relation, 1980-2018 (Non-oil Taxation)

Government Revenues	Annualized growth rates			Hodrick-Prescott filter		
	Regimes	Intercept	Slope	Regimes	Intercept	Slope
2.1.1 Taxable (T)	1981.1-1998.3	-1.346 (0.599)	1.853 (0.000)	1980.1-1992.1	-0.0003 (0.975)	1.356 (0.000)
				1992.2-1999.4	-0.001 (0.843)	3.173 (0.000)
	1998.4-2018.3	5.949 (0.000)	-0.509 (0.143)	2000.1-2012.4	-0.001 (0.854)	-0.692 (0.052)
				2013.1-2018.3	0.006 (0.580)	8.122 (0.000)
2.1.1.1 Income Taxes (ISR)	1981.1-2018.3	-0.025 (0.990)	1.900 (0.000)	1980.1-2018.3	0.000 (1.000)	2.193 (0.000)
2.1.1.2 Special Flat Rate Tax (IETU)*	2009.1-2018.3	-1.151 (0.281)	-0.042 (0.779)	2008.1-2018.3	0.0001 (0.987)	0.066 (0.599)
2.1.1.3 Tax on Cash Deposits (IDE)*	2009.1-2010.1	-4.655 (0.100)	-1.096 (0.000)	2008.1-2018.3	-0.0008 (0.869)	-0.438 (0.038)
	2010.2-2012.1	-5.361 (0.000)	0.455 (0.000)			
	2012.2-2018.3	-1.740 (0.384)	0.918 (0.090)			
2.1.1.4 Value Added Tax (VAT)	1981.1-1996.2	4.110 (0.245)	-0153 (0.790)	1980.1-1997.3	-0.003 (0.841)	0.409 (0.215)
	1996.3-2018.3	0.076 (0.942)	1.969 (0.000)	1997.4-2018.3	0.0002 (0.960)	1.922 (0.000)
2.1.1.5 Special Tax on Products and Services (STPS)*	1981.1-2002.4	2.017 (0.2748)	-0.122 (0.781)	1980.1-1991.4	-0.002 (0.651)	-0.834 (0.000)
	2003.1-2008.4	-21.417 (0.057)	2.142 (0.403)	1992.1-1997.3	-0.004 (0.688)	1.300 (0.000)
	2009.1-2018.3	61.600 (0.000)	-17.334 (0.000)	1997.4-2007.4	0.038 (0.000)	-1.487 (0.035)
				2008.1-2018.3	-0.043 (0.443)	-11.315 (0.000)
2.1.1.5.1 STPS gasoline and diesel*	1981.1-2002.4	2.098 (0.250)	-0.114 (0.795)	1980.1-1991.4	-0.004 (0.547)	-0.916 (0.000)
				1992.1-2001.3	-0.009 (0.467)	0.935 (0.027)
	2003.1-2009.2	31.620 (0.008)	-16.712 (0.000)	2001.4-2007.4	0.065 (0.000)	0.220 (0.827)

	2009.3-2018.3	138.041 (0.001)	-42.098 (0.002)	2008.1-2018.3	-0.057 (0.410)	-14.758 (0.000)
2.1.1.5.2 STPS other than gasoline and diesel*	1981.1-2018.3	0.544 (0.096)	-0.013 (0.0823)	1980.1-2018.3	0.000 (1.000)	0.016 (0.762)
2.1.1.6 Imports (IM)	1981.1-2018.3	-5.279 (0.239)	3.244 (0.001)	1980.1-2018.3	0.000 (1.000)	4.260 (0.000)
2.1.1.7 Hydrocarbon Exploration and Extraction Activity Tax (IAEEH)	1981.1-1987.4	-3.280 (0.619)	-2.176 (0.118)	1980.1-2018.3	0.000 (1.000)	0.250 (0.827)
	1988.1-1993.3	13.010 (0.182)	4.103 (0.343)			
	1993.4-1999.3	-13.846 (0.000)	2.607 (0.000)			
	1999.4-2012.4	6.119 (0.211)	-1.536 (0.181)			
	2013.1-2018.3	-17.960 (0.024)	10.565 (0.000)			

* According to the Box-Cox transformation, the amount of 100 000 was added to these variables to avoid negative values and to obtain logarithms before applying the HP filter.
Source: created by the authors with data from SHCP (2019)

During the period under analysis, some taxes were introduced that sought not only to supplement or compensate public sector revenues but also to moderate the consumption of some harmful goods or combat tax evasion. The first case is the STPS, which taxes the consumption of tobacco, alcoholic beverages, and, recently, in a significant way, gasoline and diesel. The general collection of this tax has been conditioned by that associated with fuels. As can be seen in Table 1, the total and the gasoline and diesel STPS collection present three structural changes that define four corresponding regimes. Although the year of transit from the second to the third regime differs, the estimates are qualitatively very similar when the HP filter is applied; in the case of growth rates, the period and nature of the signs and magnitudes of the regime from 2008-2009 to the end of the sample coincide. Particularly during the first decade and between 1998 (2001) and 2007, the relation with the national cycle was negative or not statistically significant. Only between 1992 and 1997 (2001) were these revenues pro-cyclical and statistically significant. In the last regime, which ran from approximately 2008 to 2018, revenues of this type were counter-cyclical and statistically significant, with a very high coefficient (-11.315 and -14.758, respectively). It is worth noting that when the international price of oil was high, the Mexican government adopted a policy of subsidizing gasoline so that during several years of the last two decades, there were negative revenues (subsidies), which may explain the sign of the estimated coefficients.[20]

Like the Single Rate Business Tax (IETU) (Spanish: Impuesto Empresarial a Tasa Unica), introduced in 2009, the STPS other than gasoline and diesel (NGD) does not have a statistically significant

[20]The instability of the coefficients of the relation between STPS and production may explain the inconclusive results of Cárdenas *et al.* (2008).

relation with the economic cycle. Other taxes that have had some relevance, although their contribution to total public revenues has been rather marginal, are the Tax on Cash Deposits (IDE) (Spanish: Impuesto a los Depósitos en Efectivo) and the Tax on Hydrocarbon Exploration and Extraction Activities (IAEEH) (Spanish: Impuesto por la Actividad de Exploración y Extracción de Hidrocarburos). In these cases, the number of structural (and regime) changes is not robust to the trend elimination method, as several are identified with growth rates and none with the HP-filtered series. Moreover, the estimated coefficients for most of the regimes have alternating signs.

Non-oil revenues include resources that go to the State's coffers as Non-Tax Revenues (NTR). According to the estimates shown in Table 3, two regimes are identified in this case. During the first, approximately throughout the first two decades of the sample, no statistically significant effect of productive activity is found, while during the second, which begins with the Great Recession, the estimates indicate an elasticity much larger than one, negative, and statistically significant. As in other cases, these results reflect the combined effect of the corresponding components. Particularly, when the HP filter is used, results analogous to those of NTR are found for the items of Products (PRO) and Profits (APR): there is a transition from one regime to another in the first half of the nineties, with a positive, elastic, and significant relation in the first one and negative or non-significant in the second one. Accessories (ACC), on the other hand, respond inelastically and negatively throughout the sample. Rights (DER), in turn, do not show a significant response to changes in productive activity. In general, these findings can be seen as a result of the gradual reduction of the state's participation in the economy, which reached a key point with the re-privatization of a multiplicity of public companies in the late 1980s and early 1990s, thus eliminating an important source of government revenue.[21]

Finally, the estimates show that Agencies and Companies (OE) revenues are stable over the entire sample period, pro-cyclical, inelastic, and statistically significant, suggesting that their lower productive activity remains in phase with the general pace of the economy.

Table 3
Estimates of the different regimes of Mexico's public revenue-to-GDP relation, 1980-2018 (non-oil, non-tax)

Government	Annualized growth rates			Hodrick-Prescott filter		
Revenues	Regimes	Intercept	Slope	Regimes	Intercept	Slope
2.1.2 Non-Taxable (NTR)	1981.1-2009.1	18.843 (0.013)	1.506 (0.335)	1980.1-2008.2	-0.011 (0.801)	1.018 (0.423)
	2009.2-2018.3	106.166 (0.000)	-22.641 (0.001)	2008.3-2018.3	-0.020 (0.756)	-13.816 (0.001)

[21]On the re-privatization process, see Cárdenas (1996). Given this trend, authors such as Figueroa (2004) argue that it is necessary to continue with the reduction of the State's entrepreneurial activity and that in order to increase tax collection, the taxpayer base in the service and transformation sectors must be broadened through greater pressure on the laws of tax justice content.

2.1.2.1 Rights (DER)	1981.1-2018.3	4.996 (0.021)	0.076 (0.898)	1980.1-2018.3	0.000 (1.000)	0.208 (0.739)
2.1.2.2 Products (PRO)	1981.1-2018.3	8.802 (0.353)	3.557 (0.292)	1980.1-1992.4	0.037 (0.638)	11.428 (0.000)
				1993.1-2018.3	-0.020 (0.605)	-0.1638 (0.365)
2.1.2.3 Profits (APR)	1981.1-2018.3	83.796 (0.003)	-0.232 (0.977)	1980.1-1995.3	-0.023 (0.842)	8.740 (0.005)
				1995.4-2018.3	0.003 (0.944)	-8.935 (0.017)
2.1.2.4 Accessories (ACC)*	1981.1-2018.3	0.084 (0.212)	-0.043 (0.065)	1980.1-2018.3	0.000 (1.000)	-0.038 (0.008)
2.2 Agencies and Companies (OE)	1981.1-2018.3	0.142 (0.912)	0.761 (0.019)	1980.1-2018.3	0.000 (1.000)	0.734 (0.012)

* According to the Box-Cox transformation, the amount of 100 000 was added to these variables to avoid negative values and to obtain logarithms before applying the HP filter.
Source: created by the authors with data from SHCP (2019)

In general, this analysis reflects the government's limited collection capacity in the face of a highly unstable oil market and, above all, with a decreasing export platform[22] and a reduced and decreasing State size that limits its alternative revenues to taxes. The significant share in total revenues and the high product elasticity of income tax and VAT collections confirm them as one of the main government financing sources.

Conclusions

This paper analyzes the relation (elasticity) between the evolution of the different types of public income and the economic cycle in Mexico from 1980.I-2018.III, enabling the possibility of statistically determined structural changes in this relation.

Even though there are differences in the estimates, the findings show several robust facts worth noting. First, according to the results previously reported in the literature, total revenues are pro-cyclical and inelastic, and their response to the economic cycle does not show structural changes. Secondly, the dynamics of oil revenues respond more to the evolution of international oil prices and, to a certain extent, to the magnitude of the export platform than to domestic productive activity. Third, non-oil revenues, on the other hand, present several regimes that can be linked to changes in tax policy as a whole. Accordingly, within tax revenues, which represent the highest proportion of the total, income tax collection is pro-cyclical, elastic, and shows no changes in its relation to productive activity. In contrast, VAT revenues are pro-cyclical after the increase in the corresponding rate to 15% to finance the fight against the 1995

[22]In view of this situation, authors such as Ibarra (2019) highlight the urgent need to transform Pemex from the financial to the productive side in order to rebuild its export capacity.

crisis.

Fourth, although total tax revenues appear to have responded significantly to the 2013 reform, specific taxes (STPS, IETU, IDE) have a highly varying relation to the economic cycle. Fifth, the relation between non-oil and non-tax revenues and the economic cycle has been negative since the first half of the nineties, which could reflect the withdrawal of the government from various activities complementary to its traditional functions. Finally, the revenues of public agencies and companies have kept pace with productive activity, so their reaction has been pro-cyclical and stable throughout the period, although inelastic.

This analysis suggests limited room for maneuver by the federal government regarding possible tax reform. It must rely on something other than oil revenues, especially with a declining export platform, and on non-oil, non-tax revenues due to the reduced and declining size of the state. In turn, the high elasticity of income tax and VAT collection shows a high sensitivity to the evolution of production. This requires efficient management of the resources obtained in the upward phase of the cycle to smooth the spending dynamics during the whole cycle.

In any case, the results presented are conditioned by the structural problems of tax collection, where tax evasion and avoidance are very high. Any proposed reform, especially if it is not only for tax collection purposes but also distributive ones, should consider institutional transformations to eradicate these vices from the Mexican tax system.

On the other hand, these results open up a research agenda that can extend the analysis toward more specific determinants of the different types of public revenue, such as consumption, oil prices, or tax collection efforts. In any case, a central implication of this analysis is that broader econometric models involving the short- and long-run relation between public revenues and their determinants should consider the possible existence of structural changes in their relation and even inquire about modifications in the individual characteristics of the variables of interest as possible determinants of such changes.

Acknowledgments

The authors gratefully acknowledge funding from the Universidad Autónoma del Estado de México through project number 4767/2019CIB, as well as the generous comments of Annel Hurtado Jaramillo and the research assistance of Anel Castillo Reyes and Salomón Sánchez Flores. The comments of the anonymous reviewers, which helped to improve this document, are gratefully acknowledged.

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