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Article

Model to estimate municipal fiscal performance using the multiple linear regression method

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Modelo para estimar el desempeño fiscal municipal utilizando un método de regresión lineal múltiple

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Abstract

The objective of this research is to determine a model to help municipalities estimate their performance in fiscal evaluations and implement actions to improve the results in their local management. The EVIEWS software was used to calculate the estimated model through multiple linear regression. The results indicate the fiscal capacity, tax autonomy, and property tax are the ones that best explain the fiscal performance of municipalities and the impact that each of these indicators has on the result of the evaluations.

Keywords: *multiple linear regression, forecast model, EVIEWS, municipal finance, fiscal performance.*

Resumen

La presente investigación tiene como objetivo la determinación de un modelo para ayudar a los municipios a estimar su desempeño en evaluaciones fiscales e implementar acciones para mejorar los resultados en su gestión local. Se utilizó el software EViews para el cálculo del modelo estimativo mediante una regresión lineal múltiple. Los resultados indican que la capacidad fiscal, la autonomía tributaria y el predial son las variables que mejor explican el desempeño fiscal de los municipios; además, muestran el impacto que tiene cada uno de estos indicadores en el resultado final de las evaluaciones.

Palabras clave: regresión lineal múltiple, modelo pronóstico, EViews, hacienda municipal, desempeño fiscal.

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Introduction

Municipal fiscal performance has been the subject of study in various research studies (Jimenez, 2015; Suzuki and Han, 2019; Wei, 2020) and, although there are multiple ways to evaluate it, depending on the specific conditions, the rise of evaluations resides in contexts of New Public Management, transparency, accountability, and intergovernmental relations, which push local governments to improve their management. Regardless of the type of government, evaluation is important; in Colombia, for example, the National Planning Department prepares a fiscal performance index to denote the state of local management of territorial divisions (Rincón Zapata and Restrepo Ruiz, 2017).

International experiences make it necessary to regulate municipal fiscal performance evaluations. Although, in Mexico, the Instituto Nacional de Estadística y Geografía (Inegi) publishes information on annual municipal revenues and expenditures, it is necessary to have financial indicators that estimate the results of local government management, strengthening transparency, accountability and local direction. Ramírez Rodríguez *et al.* (2017) consider relevant the analysis of continuous evaluations of the performance of local public finances.

Evaluations provide greater certainty in the equitable distribution of public resources among levels of government and make it possible to link financial incentives for better-performing governments and implement corrective measures for poor performers. In addition, they encourage the improvement of municipal management and seek a balance between legitimizing their existence with the citizenry and responsibly managing their budget (Bonoli *et al.*, 2019).

The literature shows the various ways of linking fiscal performance; there are those who do it from revenue, expenditure, and debt variables (Madrigal Delgado *et al.*, 2018); also, who focus on revenue and debt as static and dynamic measures of fiscal performance, where structure and local governance are related to these measures of local performance (Jimenez, 2015).

More recently, fiscal performance is associated with local spending as measured by fiscal decentralization (Makreshanska-Mladenovska and Petrevski, 2020) and by local revenue, where collection capacity, considered as a measure of horizontal-type imbalance, is related to a negative effect on fiscal performance, which is worsened when revenues as measured by capacity are unequal across municipalities (Di Liddo *et al.*, 2019).

Following these lines of thought, authors such as Wei (2020) and Tan and Avshalom-Uster (2021) associate fiscal performance with municipal structure and asymmetric decentralization. Wei argues that

municipal structure is associated with better fiscal conditions in terms of own revenues and intergovernmental dependence, which motivates better fiscal performance. Tan and Avshalom-Uster converge that asymmetric decentralization improves municipalities' own revenue participation and tax collection levels, which impacts on better fiscal performance.

Suzuki and Han (2019) analyze fiscal performance measured by indicators of fiscal autonomy and fiscal capacity in Japanese municipalities and find that citizen participation does not always lead to better fiscal outcomes at the municipal level.

In this sense, the purpose of this document is to determine a model to help municipalities to estimate their performance, implement the document also proposes actions to improve the results of their management and, in addition, to allow municipal governments to correct inefficiencies and improve their fiscal performance. Although the literature provides evidence on the various variables that are related to local performance, this document provides certainty on the variables that best estimate the performance of municipal governments, through the proposal of a model, which was estimated with the multiple linear regression method, where fiscal performance is the estimated variable and the explanatory variables are own revenues, the capacity to cover expenditures with own resources and the proportion of property tax.

It was statistically proven that the model is good, because it estimates 94.27% of the performance, and the error it showed at the beginning (multicollinearity) was solved by excluding variables that disturbed it. The exclusion was statistically supported. The variables were constructed with 2018 data from Inegi's municipal public finances, which were subjected to the multiple linear regression process to obtain the estimated model of fiscal performance. At the end, a test of the proposed model is performed, comparing its result with an index used in previous research (Madrigal Delgado *et al.*, 2018), normalized on the same scale of 0-1, to see the practical effectiveness of the model proposed in this research.

Multiple linear regression was used because when working with data on indicators it is possible that there are problems of multicollinearity and autocorrelation, in addition to being a method used in similar research on municipal fiscal performance (Suzuki and Han, 2019; Jimenez, 2015). However, generalized methods of moments and factor analysis have also been used for fiscal performance studies (Di Liddo *et al.*, 2019; Wei, 2020); however, the use of multiple linear regression allows using the ordinary least squares technique to minimize the residuals and obtain the best fitting equation.

Finally, this research is considered important because while the literature on municipal fiscal performance provides empirical and

theoretical data on its relationship with static and dynamic aspects (e.g., revenue and debt), little is known statistically about how much each variable or set of variables estimates fiscal performance.

The rest of the document is organized as follows: section 1 reports on the multiple regression in fiscal performance evaluations and the explanatory variables of fiscal performance; section 2 explains of the multiple linear regression method used to determine the model; both sections introduce the index and the method used by other authors, with which the estimated model determined in this study is compared; section 3 shows the results of the empirical analysis. Finally, the conclusions are presented.

1. Multiple regressions in municipal fiscal performance evaluations

The above underscores the importance of fiscal performance, the ways of approaching it and the relevance of using indicators in its evaluation. In this research, multiple linear regression is used to determine a model for estimating municipal fiscal performance. Multiple regression is a statistical method, which serves as a descriptive and inferential tool, requiring tests for heteroscedasticity, multicollinearity, and specification to try to fit linear models (Montero-Granados, 2016), where the variables must be statistically significant to explain the dependent variable and calculate the regression model.

Regression has been used in previous research on fiscal performance; for example, Suzuki and Han (2019) used it to analyze, using panel data, Japanese municipalities; Jimenez (2015), for his part, in the study of local governments in the United States; and Medina Álvarez and Indaluque Arapa (2020) used it to demonstrate the components that affect the level of compliance with local government works in Peru.

The literature on fiscal performance provides the opportunity to use various variables that could estimate the performance of municipalities. Although specific analyses of the fiscal performance of governments date back decades (Tiebout, 1956; Oates, 1999), recent studies show the various interrelationships or ways of approaching it at the local level, but, in general, they relate it to revenue, expenditure or debt (Di Liddo *et al.*, 2019; Madrigal Delgado *et al.*, 2018; Makreshanska-Mladenovska and Petrevski, 2020), although some group them as static and dynamic aspects (Jimenez, 2015).

Among other possibilities, there are variables such as financial and tax autonomy, financial dependence, fiscal and financial capacity, financial leverage, spending discretionarily and property collection (Madrigal Delgado *et al.*, 2018); specifically, variables of government

functioning in terms of revenue and expenditure are also addressed, such as the study on municipalities in Colombia (González Henao and Rodríguez-Valencia, 2009).

As a first approach to the interior of the country, all variables are of interest, however, in the development of the multiple linear regression method only some will be statistically significant. Being significant in the model refers to the fact that, taken together, the variables estimate an important part of the performance and do so without causing errors in the model. Because the regression identifies the indicators that best estimate performance, it provides accurate information to improve performance and helps municipal governments to correct inefficiencies. Anticipating results is a preventive tool in local management. This will help the central government to estimate municipal fiscal performance scores, which will allow it to implement measures to address groups of municipalities that share the same shortcomings, but also to assess the high scores of municipalities with incentives, which will encourage them to improve their performance. In the same way, it provides information for the design of transfers that motivate to improve local tax collection.

1.1. Variables explaining fiscal performance

As established in the previous section, multiple linear regression is used in this research because the purpose is to determine a model that allows estimating municipal fiscal performance. To achieve this, it is indisputable that performance explanatory variables must be used; this is the intention of the present study: to elucidate which variables explain part of the fiscal performance, in particular, focused on revenues, expenditures, or debt, which, according to the statements made in the introduction, are the elements considered in fiscal performance studies.

The lack of resources at the municipal level is undeniable in local governments mexicans (Espinosa *et al.*, 2018; Unda Gutiérrez, 2017 and 2018; Unda Gutiérrez and Moreno-Jaimes, 2015), however, this is not a generalized problem because, contrary to what might be thought, there is high local revenue collection supported in some entities (Madrigal Delgado, 2021), due, in part, to the particular dynamics and the large differences that exist between the country's municipalities, which is why the analysis of municipal revenue collection is relevant.

Madrigal Delgado (2021) uses as variables the collection of property tax and all property taxes, both ratios in relation to the gross domestic product of the entity; he finds that the collection of all property taxes, in most of the entities, did not increase during the study period and emphasizes that the national collection is supported by five entities that, together with Mexico City, collect 70% of the national total.

For their part, Unda Gutiérrez and Moreno-Jaimes (2015) determine the ratio of revenues from local sources as a percentage of total revenues and show that since 2001 the proportion of local revenues has been declining, since municipalities began to receive resources from contributions in 1998.

Therefore, fiscal autonomy becomes important; this is defined as the percentage of the entity's own revenues with respect to total revenues. According to this school of thought, municipal taxation powers are important because they increase the entity's own sources of revenue and lead to greater autonomy. Moreover, it is believed that increasing this variable leads to better public services (Oates, 1999). Consequently, in the face of limited fiscal autonomy, local governments are subordinated to the will of the federation and are less likely to have a positive impact on municipal administration.

In essence, fiscal autonomy addresses the revenues of municipal finances and is measured as the total collection of municipal revenues, while fiscal capacity addresses municipal revenues and expenditures, therefore, it is the ratio of municipal resources to local public needs; it reflects the degree to which municipal governments meet citizens' requests for goods and services with their own resources (Suzuki and Han, 2019). The essential services provided by municipalities and their ability to pay for them are relevant in fiscal performance studies, according to the contribution of Switzer *et al.* (2020), who mention that public services such as water, wastewater and electricity are essential, even in times such as the covid-19 pandemic and must be maintained; not doing so increases the risk of pandemic.

Although in federal systems there is a tendency to blame other levels of government for limited resources, the truth is that local governments have fewer resources, and it is more difficult for them to get out of crises without external help from the state or federation. Therefore, own resources are decisive in the fiscal capacity to finance, at least, mandatory expenditures and influence the resolution of spending. For Shah (1994), if local governments cover an important part of their expenditures with their own resources, decisions are more efficient, because they allocate the cost to the effort of their own jurisdiction.

The above coincides with the flypaper theory, which attributes the increase in subnational spending, when the source of income is external, to the one that exercises the expenditure, because the cost of financing expenditures corresponds to other levels and not to the own effort. Díaz González and Montelongo Jaime (2017) find evidence of the flypaper effect especially in entities highly dependent on government transfers; they point out that the growing dependence of subnational governments on government transfers is a consequence of the flypaper effect financial dependence brings with it an increase in public spending. As a result, the local governments tend to spend a lot, because the money does not involve their own effort and, therefore,

there is a growth in current spending when it is financed with transfers.

The flypaper effect arises simply because public expenditures become cheaper when financed with transfers (Sepúlveda, 2017), a situation widely accepted in the flypaper literature (Sour, 2016). Transfers allow a shift to current spending, which becomes more than half of total expenditures.

With the intention of strengthening local finances, in 1999 Article 115 of the Constitution was amended, aimed at increasing municipal capacity and power in property tax; however, it is shown that the reform was unable to mitigate the limitations of the first reform of 1982, causing a decrease of 94.4 pesos per inhabitant in the average property tax per state, despite the attempt to grant powers for the management of the tax (Unda Gutiérrez and Moreno-Jaimes, 2015).

Even though property tax is considered the black gold of municipalities, the meager revenues are below potential. For Mexico, Argentina and Brazil, the squandering of tax powers, spending slippage and the increase in public debt have led to a reduction in fiscal space (ECLAC, 2019).

Property tax is a feasible indicator to evaluate fiscal performance, among other reasons, because it is of interest in municipal management and financing issues; it is a source of municipal revenues and a tax with great potential; it is the most important resource for municipalities in many parts of the world; in Mexico, it is the main instrument for taxing wealth and wealth (Ruelas Ávila, 2015).

On average, property tax represents 66% of property taxes in Mexico; this implies that it is "the main tax instrument for generating municipal revenues and, in turn, the most widely used tool for taxing property" (Madrigal Delgado, 2021: 144). However, the literature points to low property tax collection because Mexico occupies the last places among the members of the Organization for Economic Cooperation and Development, a situation that has persisted for the last 20 years, and also in Latin America. When comparing the evolution of property taxes, in Mexico it symbolizes 0.19% of gross domestic product (GDP), while in Argentina, Brazil, Colombia and Panama it ranges from 0.35% to 0.60% (De Cesare, 2016). This shows the low local collection of this tax with great potential. Therefore, it is convenient to find out what are some of the causes of these poor results in the collection of this and all local taxes. Studies show that low local revenue collection is due to transfers, which encourage fiscal laziness. Canavire-Bacarreza and Zúñiga Espinoza (2015) point out a harmful impact on municipal tax revenue collection, where conditional transfers have a greater impact on property tax collection. Espinosa *et al.* (2018) suggest a positive effect of unconditional transfers on property tax collection performance and support the fact that conditional transfers decrease collection efficiency.

There are those who consider that the main limitation meets in rural municipalities, due to the low cost of the rustic domain, to the limited administrative capacity in these municipalities and to the historical dispensation of the ejido (Unda Gutiérrez and Moreno-Jaimes, 2015). In this sense, it is relevant to focus on some capacity and management indicators to evaluate property tax collection.

Under the above consideration, property tax is the primary source of tax revenue, so its analysis provides tools that lead to strengthening local finances, so it is important to identify the factors that have a positive impact on its collection. Espinosa *et al.* (2018) provide some factors: uniformity in cadastral valuation processes and the mandate to have an updated geographic registry with annual revision, ensuring information quality and homogeneity in municipalities within entities.

Other research refers to the modernization of the cadastre. In a study, Ruelas Ávila (2015) mentions that 76% of mexican municipalities do not have updated cadastral information, and those that have with updated cadastral information, 50% is not in accordance with market values, which evidences that the outdatedness of the cadastral value according to that of the market continues to be a difficulty for the collection system. Unda Gutiérrez (2018) considers that the reason for the low local collection is due to the disinterest of the mayors and the lack of promotion on their part, of increases in tables, rates and updating of cadastral values due to political interests and what in the literature is identified as a political cost that local governors do not want to pay.

Unda Gutiérrez (2017) points to cadastral values, tax rates and collection efficiency; he shows that the latter is determined by institutional capacity, specifically in the area of cadastre and revenue management. Institutional capacity, defined as the ability of governments to achieve their objectives, is a determining factor in motivating property tax collection. A subsequent study finds a positive correlation between the treasury and cadastre institutional capacity indexes with the property tax index, suggesting that institutional capacities have an impact on property tax collection (Unda Gutiérrez, 2018).

In view of this, the challenges faced by local governments in the collection of this tax can be observed, such as: the administration of the cadastre, the updating of cadastral values and institutional capacity. Therefore, the assignment of tax powers not only implies a reform in this area, but also involves a strategy of financial, administrative, and collaborative support to strengthen the institutional capacities of local governments, to achieve the expected results of the reform. The literature has evidenced shortcomings in local tax collection; however, it is important to strengthen their institutions.

2. Materials and methods

2.1. Towards the determination of the estimation model

The proposed model for estimating the fiscal performance of municipalities is determined by using multiple linear regression, which is feasible in performance evaluation studies of local governments.
In addition, the ordinary least squares technique is used to obtain the equation of the line, which allows minimizing the residuals. Both selections, method, and technique, have been used in related research, and their use achieves the proposed objective.

The objective of this research was to determine a model to help municipalities estimate their performance, implement actions to improve their management results and correct inefficiencies. For this purpose, research was carried out to determine a model to help municipalities estimate their performance, implement actions to improve their management results and correct inefficiencies quantitative research, collecting data on the income and expenditures of 2441 municipalities of the country in 2018. The information was obtained from Inegi (2018), in the section on state and municipal public finances; for population data, the population projections of the National Population Council (Conapo, 2019) were used.

The multiple linear regression allows statistically knowing which variables together allow estimating fiscal performance, in addition to identifying the impact that some action by the municipal governments may have on the performance result.

To carry out the multiple linear regression, graphical and numerical tests were performed to ensure that the model is reasonably good. Numerical tests were performed to detect specification errors, heteroscedasticity and multicollinearity (Montero Granados, 2016).
The variable of interest, or dependent variable, is the municipal fiscal performance index resulting from the factor analysis applied with the proposed methodology (Madrigal Delgado *et al*., 2018); while the explanatory or regressor variables are: fiscal capacity, financial autonomy, equity, tax autonomy and property, which, according to local government management literature, are an important guide to know their performance.

Considering the explanatory variables and the variable of interest, the model is based on a multiple regression in the following form (equation 1):

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \varepsilon \qquad (1)$$

In this model, the value of Y corresponds to municipal fiscal performance (DFM), while the values of X_1, X_2, X_3, X_4 and X_5 correspond to fiscal capacity, financial autonomy, equity, tax autonomy and property, respectively.

The DFM elaborated through the factor analysis procedure estimates results between 0-1, where 0 indicates zero municipal fiscal performance; values closer to 0 indicate lower performance; values closer to 1 refer to higher fiscal performance of the municipality.

Considering the divergence in the characteristics of the country's municipalities, the resulting values are grouped into five levels of fiscal performance, as applied by Conapo; to group them, the position measure for non-grouped data was used, which allows for establishing ranges between the proposed categories (table 1).

Table 1
Categories of municipal fiscal performance

Category	*From*	*To*
Very low	0	0.079
Under	0.08	0.099
Medium	0.10	0.149
High	0.15	0.399
Very high	0.40	1

Source: own elaboration.

Once the estimation model equation was obtained, its result was compared with an index established by other authors (Madrigal Delgado *et al.*, 2018), to validate, in a practical way, that the model is good for estimating performance. It is worth mentioning that the index with which the result of the estimative model is compared was also normalized to values of 0-1.

To obtain the index with which the result of the estimation model proposed in this research was compared, the pertinent feasibility tests were carried out, as explained below:

- The analysis of the correlations in the correlation matrix indicated that it is possible to group them into dimensions.

- The Kaiser-Meyer-Olkin index (KMO) showed a result greater than 0.50, indicating the feasibility of performing the analysis.

- Bartlet's test showed a significance level of less than 0.05, confirming the feasibility of the study using the proposed method (table 2).

Table 2
KMO test and Bartlett's test

2018		
KMO measure of sampling adequacy		0.7
Bartlett's test for sphericity	Approx. chi-square	85930.454
	Degrees of freedom	210
	Significance	0

Source: own elaboration with SPSS *software*, version 23 (IBM, 2016).

The following section defines the variables used in the proposed fiscal performance estimation model.

2.2. Multiple linear regression and the explanatory variables in the estimation model

The explanatory variables of the proposed model are as follows; their operationalization is shown in table 3.

- The fiscal capacity to cover current expenditures evidences the municipality's ability to cover current expenditures with the amount of taxes collected in its jurisdiction.

- Financial autonomy is the degree of independence of the municipality, because it represents the proportion of own revenues with respect to total municipal revenues; it is the quotient resulting from dividing own revenues by total revenues.

- Tax autonomy is the proportion of municipal revenues corresponding to taxes.

- The per capita wealth tax is the result of dividing the collection of all wealth taxes by the municipal population.

- The per capita property tax is the result of dividing the predial collection by the municipal population.

Table 3
Operationalization of the explanatory variables of the fiscal performance model

Variable	*Quotient*
Fiscal capacity	*Taxes*
	Current Expenses
Financial autonomy	*Own resources*
	Total income
Tax autonomy	*Taxes*
	Own resources
Per capita wealth tax	*Wealth taxes*
	Total Population
Predial per capita	*Predial*
	Total population

Source: own elaboration.

It should be noted that five explanatory variables were included, while the dependent variable is the DFM, which is represented by the index used for comparative purposes. In general terms, the following explains how the multiple linear regression method yielded the variables that, as a whole, best estimate the municipal performance scores. As a first step, we proceeded to review the significance of the variables, where it was found that all five are statistically significant, although they presented multicollinearity problems, which were solved; below, we explain how this was resolved:

The level of significance of the variables and of the model in general was tested in equation 2. The five variables were significant; however, multicollinearity was found according to the variance inflation factor FIV. Therefore, we proceeded to check the correlation between each independent variable, detecting high correlation between two variables; by means of auxiliary regressions, we measured the effect of excluding two variables with high correlation and this allowed us to solve the problem. Since including five variables is a source of multicollinearity, it was decided to reduce the number of explanatory variables to three, thus mitigating the error.

The Klein rule detection test in the selected model, when excluding two variables, showed that there is no multicollinearity; in addition, the IVF factor dropped considerably, resulting in a statistically significant and reasonably good model for forecasting the municipal index. The results are presented in greater detail in the section on results. The following section details the results of the multiple linear regression model for estimating the fiscal performance of municipal governments. The predictive model is advantageous; it is more so in times of non-certainty in the distribution of resources and in contexts

of high centralization of revenues in the central government. Moreover, it is functional in realities where, despite efforts to increase the taxing powers of local governments, its results are scarce.

Finally, it should be mentioned that an estimation model allows governments to anticipate their management results and thus have a useful tool for developing improvement strategies through the follow-up and monitoring of predictor indicators or explanatory variables.

3. Results

3.1. Estimation of the model from multiple linear regression

The synthetic index and the explanatory variables were subjected to multiple linear regression in EViews software (S&P Global, 2017). The ordinary least squares (OLS) technique was used to calculate the linear regression line that minimizes the residuals, i.e., the difference between actual and estimated values. This technique is widely used in public administration studies (Goeminne and George, 2019) to obtain the slope of the line and the ordinate that best fits the data.

In a first output, the model is significant at 5%, since it was found that the five independent variables pass the t-test, being greater than the tt. Overall, the model is also significant, as the calculated f is greater than ft (table 4) and is presented in equation 2. However, as mentioned, there was a multicollinearity problem, which was detected with the variance inflation factors (VIF), which measures the correlation between the predictors, i.e., the variables (table 5).

Reviewing the correlations between the variables, we detected some with a high association, which shows a problem of multicollinearity. To correlate this, it was decided to eliminate the variables with the highest association, so that they would not disturb the model; in the table 6 shows the results extracted from EViews, which confirmed the correlation between the variable X1 and X2, as well as between X3 and X5.

Table 4
Least squares estimation with five variables

Dependent variable: municipal fiscal performance

Variable	*Coefficient*	*Standard error*	*Statistics t*	*Probability*
C	0.074121	0.000607	122.1799	0.0000
X_1 Fiscal capacity	0.745780	0.015542	47.98390	0.0000
X_2 Financial autonomy	0.392643	0.011029	35.60162	0.0000
X_3 Heritage	2.71E-05	2.84E-06	9.536876	0.0000
X_4 Tax autonomy	0.024476	0.001964	12.46457	0.0000
X_5 Predial	4.02E-05	4.96E-06	8.106006	0.0000
R-squared	0.963239	Mean dependent var		0.137121
Adjusted R-squared	0.963164	S.D. dependent var		0.107534
F-statistic	12760.86	Durbin-Watson stat		0.982300
Prob(F-statistic)	0.000000			

Source: own elaboration based on statistical calculations performed in EViews, version 10 (S&P Global, 2017).

$$Y = 0.074121 + 0.745780 * X_1 + 0.392643 * X_2 + 0.392643 * X_3 + 2.71E\text{-}05 * X_4 + 4.02E\text{-}05 * X_5 + \varepsilon \quad (2)$$

Table 5
Variance inflation factor

Remarks include: 2441

Variable	*Coefficient Variance*	*Not centrar VIF*	*Focused VIF*
C	3.68E-07	2.109023	NA
X_1 Fiscal Capacity	0.000242	9.904583	7.816511
X_2 Financial Autonomy	0.000122	8.384363	6.012212
X_3 Heritage	8.06E-12	5.478230	5.056661
X_4 Tax autonomy	3.86E-06	2.922881	1.570503
X_5 Predial	2.46E-11	5.072016	4.531848

Source: own elaboration based on statistical calculations performed in EViews, version 10 (S&P Global, 2017).

Table 6
Correlations between independent variables

	X_1 *Fiscal capacity*	X_2 *Financial autonomy*	X_3 *Heritage*	X_4 *Tax autonomy*	X_5 *Predial*
X_1 Fiscal capacity	1.000000	0.911424	0.678290	0.588471	0.632197
X_2 Financial autonomy	**0.911424**	1.000000	0.626354	0.492851	0.583348
X_3 Heritage	0.678290	0.626354	1.000000	0.363240	**0.880813**
X_4 Tax autonomy	0.588471	0.492851	0.363240	1.000000	0.370414
X_5 Predial	0.632197	0.583348	0.880813	0.370414	1.000000

Source: own elaboration based on statistical calculations performed in EViews, version 10 (S&P Global, 2017).

The results showed that, in the case of the regression involving X_1 with X_2 and X_3 with X_5, the score of the adjusted coefficient of determination is virtuous. Given this, the presence of multicollinearity is evident. Regressions were performed to measure the effect by excluding at least one of the variables of each correlated pair (table 7):

Table 7
Multiple auxiliary regressions

Multiple auxiliary regressions	*Statistics*				
	F	R^2	RA^2	*t*	
Using Y C X_1 X_4 X_5	13365.92	0.9426	0.9426	113.79	5.62
$Y=0.080971+1.231325*X_1+0.013595*X_4+8.02^{E}-05X_5+\mu_t$				119.70	21.37
Using Y C X_1 X_3 X_4				115.08	21.73
$Y=0.081684+1.206911*X_1+4.66E-05*X_3+0.016636*X_4+\mu_t$	13441.51	0.9430	0.9429	111.02	6.88
Using Y C X_2 X_4 X_5				77.34	22.76
$Y=0.064567+0.863046*X_2+0.059667*X_4+0.000120*X_5+\mu_t$	9758.681	0.9231	0.9230	100.31	28.81
Using Y C X_2 X_3 X_4				81.04	31.85
$Y=0.066243+0.832784*X_2+7.28E-05*X_3+0.062019*X_4+\mu_t$	10355.20	0.9272	0.9271	95.55	24.41

Source: own elaboration based on statistical calculations performed in EViews, version 10 (S&P Global, 2017).

It was decided to choose one of the previous models; for this, the significance level of the estimators that directly affect the explanatory variable was considered, without leaving aside the *F* and R^2 statistical values. With these considerations, we chose the model that has fiscal capacity, tax autonomy and per capita property tax as explanatory variables (table 8) and, once again, we used OLS to obtain the regression that best fits the data.

Table 8
Least squares estimation with three variables

Dependent variable: municipal fiscal performance

Variable	*Coefficient*	*Standard error*	*Statistics t*	*Probability*
C	0.080971	0.000712	113.7965	0.0000
X_1 Fiscal capacity	1.231325	0.010286	119.7037	0.0000
X_4 Tax autonomy	0.013595	0.002418	5.621369	0.0000
X_5 Predial	8.02E-05	3.75E-06	21.37305	0.0000
R-squared	0.942706	Mean dependent var		0.137121
Adjusted R-squared	0.942635	S.D. dependent var		0.107534
F-statistic	13365.92	Durbin-Watson stat		1.397109
Prob(F-statistic)	0.000000			

Source: own elaboration based on statistical calculations performed in EViews, version 10 (S&P Global, 2017).

Once the explanatory variables of the model were selected, the presence or not of multicollinearity was checked using Klein's rule, the

variance inflation factor, and the ellipse graph. The results with the Klein rule show that there is no multicollinearity, since the R2 of the auxiliary regressions in all cases are lower than the R2 of the original regression (table 9).

Table 9
Multiple coefficients of determination

Original regression	*Auxiliary regressions*		
R^2 of the regressions	X_1 Fiscal capacity	X_4 Tax autonomy	X_5 Predial
0.942706	0.545161	0.346303	0.399677

Source: own elaboration based on statistical calculations performed in EViews, version 10 (S&P Global, 2017).

The contemporaneous multicollinearity detection measure of the variance inflation factor VIF shows values close to unity and, being less than five, indicate that the values are moderately correlated. These results show that the model does not have multicollinearity problems. That is, by eliminating two highly correlated variables, the problem of multicollinearity was corrected (table 10).

Table 10
Variance inflation factor of forecast model variance

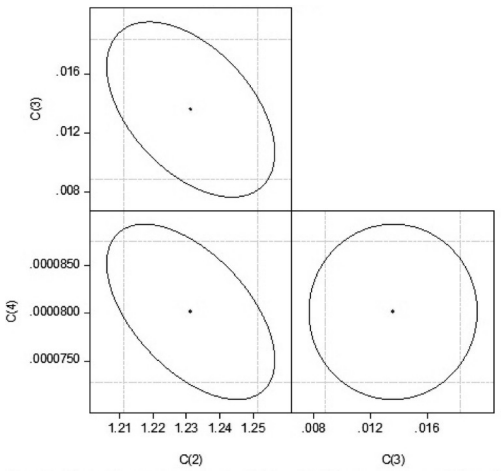
Remarks include: 2441

Variable	*Coefficient Variance*	*Not centered VIF*	*Focused VIF*
C	5.06E-07	1.863087	NA
X_1 Fiscal capacity	0.000106	2.785898	2.198578
X_4 Tax autonomy	5.85E-06	2.847053	1.529760
X_5 Predial	1.41E-11	1.864318	1.665769

Source: own elaboration based on statistical calculations performed in EViews, version 10 (S&P Global, 2017).

In addition, the ellipse graph shows the relationship between variables: when the relationship is low, the graph tends to be a circle; it is an ellipse in the case of a high relationship. The graphs tend to be circles without becoming circles, which shows the moderate correlation between the variables (graph 1).

Graph 1
Ellipse chart

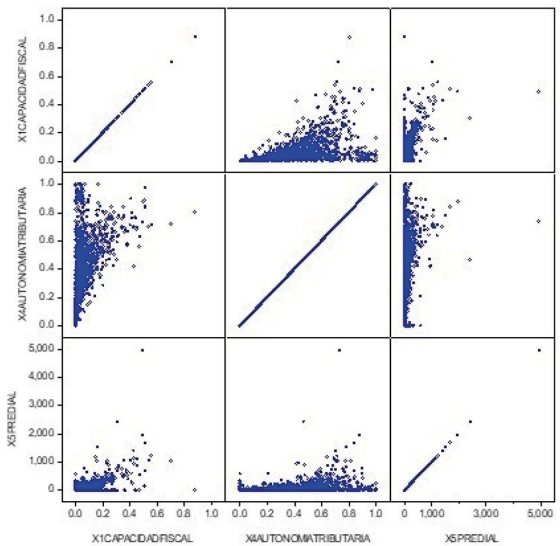


Source: own elaboration based on statistical calculations performed in EViews, version 10 (S&P Global, 2017).

Also, the scatter plots between the regressions in the following matrix show the low association between the explanatory variables (graph 2).

As can be seen, financial autonomy was highly related to fiscal capacity; on the other hand, equity was related to property, which made multicollinearity present in the original model; this problem was solved by eliminating from the model two variables that were highly related within the, selecting the model with the highest R^2 and the one that best solves the problem, considerably lowering the VIF values.

Graph 2
Scatter plots



Source: own elaboration based on statistical calculations performed in EViews, version 10 (S&P Global, 2017).

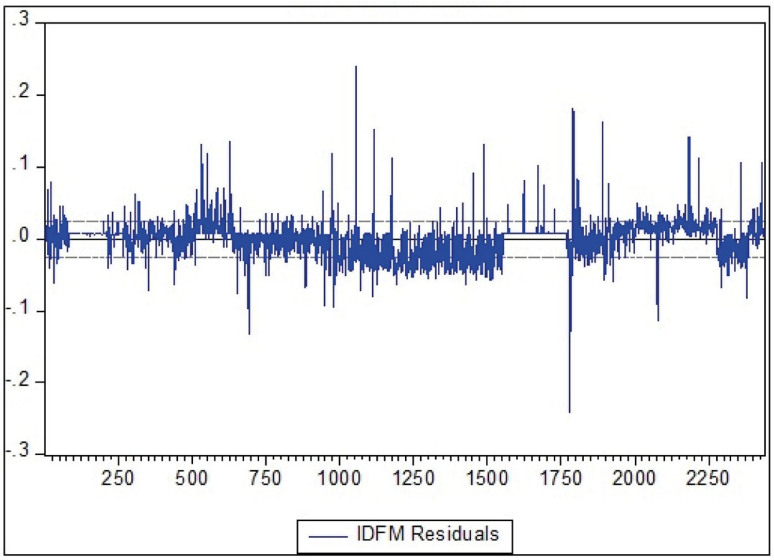
After verifying that the selected model did not have multicollinearity problems, like the original model, we proceeded to perform the heteroscedasticity tests, using several methods, starting with the variance of the errors, the Breusch-Pagan-Godfrey test, and the White test. All three showed the presence of heteroscedasticity in the model, so the values were trans- formed to mitigate the problem and, subsequently, the autocorrelation test was performed, which showed that the model is not autocorrelated; this was done by means of the Durbin Watson value.

This is explained below with the corresponding graphs: The variance of the errors is different; this shows that there is heteroscedasticity (graph 3). The Breusch-Pagan-Godfrey test and the White test (table 11) also proved its presence, since the values of the probabilities (prob) are less than 0.05, which refutes the null hypothesis and confirms the presence of heteroscedasticity. Likewise, when the calculated chi is greater than the table chi, the existence of heteroscedasticity is shown, so we proceeded to solve the problem by obtaining transformed values (table 12).

Corrected for heteroscedasticity, the forecast model is presented in equation 3:

$$Y = 0.080971 + 1.231325 * X_1 + 0.013595 * X_4 + 8.02E-05X_5 + \mu_t \quad (3)$$

Graph 3
Error variance



Source: own elaboration based on statistical calculations performed in EViews, version 10 (S&P Global, 2017).

Table 11
White test for heteroscedasticity

F-statistic	*109.3926*	*Prob. F (9,2431)*		*0.0000*
Variable	*Coefficient*	*Standard error*	*Statistics t*	*Probability*
C	0.000536	6.22E-05	8.616876	0.0000
X_1 Fiscal capacity ^2	-0.086014	0.004072	21.12216	0.0000
X_1 Fiscal capacity * X_4 Tax autonomy	-0.057390	-0.005749	-9.982431	0.0000
X_1 Fiscal capacity * X_5 Predial	-2.72E-05	2.59E-06	-10.50496	0.0000
X_1 Fiscal capacity	0.022826	0.003387	6.738458	0.0000
X_4 Tax autonomy ^2	0.003515	0.000755	4.657654	0.0000
X_4 Tax autonomy X_5 Predial	-4.20E-06	2.09E-06	-2.010662	0.0445
X_4 Tax autonomy	-0.002589	0.000581	-4.457586	0.0000
X_5 Predial ^2	2.20E-09	1.91E-10	11.55101	0.0000
X_5 Predial	6.20E-06	1.18E-06	5.241535	0.0000
R-squared	0.288252	Mean dependent var		0.000662
Adjusted R-squared	0.285617	S.D. dependent var		0.002434
F-statistic	109.3926	Durbin-Watson stat		1.953747
Prob(F-statistic)	0.000000			

Source: own elaboration based on EViews, version 10 (S&P Global, 2017).

Table 12
Transformed values

Dependent variable: transformed fiscal performance

Variable	*Coefficient*	*Standard error*	*Statistics t*	*Probability*
C	1.370240	0.909925	1.505882	0.1322
X	0.020075	0.002652	7.569607	0.0000
Z	-0.000401	0.000381	-1.052624	0.2926
W	0.058142	0.000348	166.8716	0.0000
R-squared	0.923014	Mean dependent var		16.29796
Adjusted R-squared	0.922919	S.D. dependent var		137.7766
F-statistic	9739.321	Durbin-Watson stat		2.001417
Prob(F-statistic)	0.000000			

Source: own elaboration based on EViews, version 10 (S&P Global, 2017).

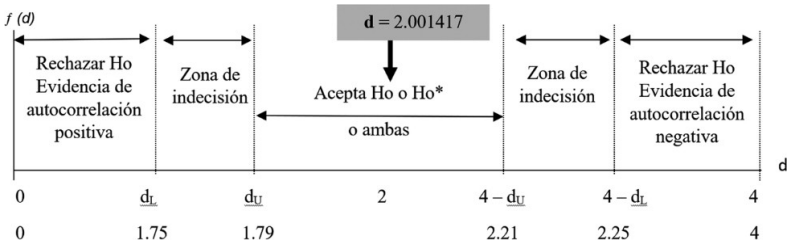
Subsequently, the autocorrelation was looked at. The Durbin-Watson value is 2.001417, so it is assumed that the model is correct and has no presence of autocorrelation (graph 4), because the values found in the D-W table are:

$$d_L = 1.7\ d_u = 1.79$$

therefore:

$$4\text{-}d_L = 4\text{-}(1.75) = 2.25 \text{ and } 4\text{-}d_U = 4\text{-}(1.79) = 2.21.$$

Graph 4
Durvin-Watson



Source: own elaboration.

Consequently, the following section presents the forecast model for the fiscal performance of local governments. The selected model is developed according to the explanatory variables -fiscal capacity, tax autonomy and property tax- to estimate the result of the synthetic index. The result of the predicted index is also compared with the synthetic index and it is verified that the model is efficient. In addition, valuable information is shown regarding the variability that the index would have in the face of a positive or negative variation of the indicators.

3.2. Model for estimating municipal fiscal performance

The DFM model allows estimating the performance of municipal governments with three explanatory variables: fiscal capacity, tax autonomy and property tax collection. This multidimensional aspect allows local treasuries to focus efforts on relevant areas such as revenues, expenditures and tax revenue collection, since the model considers indicators in these areas (equation 4). More importantly, the model can be used to correct inefficiencies in local governments and improve their municipal performance.

$$\text{DFM} = 0.080971 + 1.23131325 * X_1\ \textit{fiscal capacity} + 0.013595 * X_4\ \textit{autonomy-tax} + 8.02\text{E-}05X_5\ \textit{property} + \mu_t \quad (4)$$

Based on the estimated model, the value of B0=0.080971 represents the municipal performance score when fiscal capacity, tax autonomy and property tax have the value of zero. The interpretation of the model is as follows:

i) for each unit increase in the fiscal capacity variable or predictor, fiscal performance increases by 1.23131325 units, with the rest of the predictors remaining constant;

ii) for each unit increase in the tax autonomy variable, the DFM increases on average 0.013595 units, with all other predictors remaining constant; and

iii) for each unit increase in the predictor property, performance increases by an average of 0.00008802 units, with all other predictors remaining constant.

As can be seen, the predictors, individually in the model, explain part of the municipal fiscal performance, when the rest remains constant; however, together they explain 94.27% of local performance, with the intervention of all three being beneficial in the model. In addition, the three variables have a directly proportional relationship with municipal performance, because with an increase in these variables, performance also increases.

The estimated model is very close to the synthetic index determined with the methodology of Madrigal Delgado *et al.* (2018) and is reasonably good for estimating municipal fiscal performance. Table 13 presents the application of the model that estimates fiscal performance, considering, for convenience, a sample of five municipalities in the country, which were selected with simple random sampling, which guarantees that any municipality has the same probability of being chosen (López-Roldán and Fachelli, 2015). For this, first the synthetic index is determined with the methodology of Madrigal Delgado *et al.* (2018) (column three); next, the predictors of the performance estimation model are presented (columns four, five and six); finally, fiscal performance is estimated with the proposed model (equation 4; column seven). As can be seen, a sample of municipalities representative of the four performance categories proposed in the study was drawn. The model is good because with fewer indicators its result is close to the synthetic index taken as a reference, due to the validity tests performed.

Table 13
Estimation of municipal fiscal performance

Municipality	*Performance category*	*Synthetic index*	*Predictors*			*Estimation of municipal fiscal performance*
			Fiscal capacity	*Tax autonomy*	*Predial*	
Los Cabos, B.C.S.	Very high	0.751387	0.4528	0.6979	1108.79	0.7370
Aguascalientes, Ags.	High	0.340566	0.1563	0.4498	254.91	0.3000
Escarcega, Camp.	Medium	0.137872	0.0424	0.4411	102.00	0.1474
San Dimas, Dgo.	Medium	0.094936	0.019501	0.240222	42.32	0.1116
San Felipe Orizatlan, Hgo.	Under	0.071883	0.011219	0.255592	17.40	0.0997

Source: Prepared by the authors based on the calculations developed in the research.

In addition, the model yields a very important fact for public management theories, and this is related to the fact that those municipalities that implement strategies to improve the fiscal capacity variable will have a favorable impact greater than unity in their fiscal performance. In other words, actions aimed at covering expenditures with resources from their own jurisdiction favor their performance results. Likewise, the increase in tax revenues promotes better fiscal performance of the municipalities, being important the indicator of property collection per inhabitant.

For purposes of exemplifying the incidence of the predictor indicators in the model (equation 4), it was found that an increase in the fiscal capacity and tax autonomy index of 10% and an increase of 100 pesos in property tax collection in San Felipe Orizatlan, Hidalgo, positively impacts municipal fiscal performance by 24% more with respect to the 2018 score, positioning the municipality at 0.1240 points.

This assumption shows that, in practice, municipal governments can implement strategies to increase their position in the ranking and improve their fiscal performance through efficiency in local management. Above all, this predictive tool for local management assesses aspects of transfer design, the results of reforms and the equitable and fair distribution of resources.

Conclusions

Performance evaluations of local governments have grown in recent years, a trend that will continue in the Mexican context, due to intergovernmental relations and the consequent search for a fairer distribution of wealth among governments. Historically, the central government collects more revenue, leaving a reduced share to local regency. Despite reforms aimed at strengthening local finances by

giving greater powers to municipal management, local revenue collection is poor. Only a few municipalities concentrate the largest national collection of property taxes. This paper contributes to public management theory by proposing a multiple linear regression model to estimate municipal fiscal performance results, which can serve as an incentive parameter for municipalities with better ranking and as a management and incentive strategy for those with lower performance.

Specifically, the most relevant indicators of the municipal fiscal performance index were identified, which are statistically significant and capable of measuring the fiscal performance of the municipalities. The following were used to estimate the municipal index: fiscal capacity, autonomy, autonomous tax and property taxes. It was observed that fiscal capacity, measured as the independence of municipalities to cover expenditures with their own resources, has a greater impact on the predicted index. Therefore, increasing the predictive indicators leads to better municipal fiscal performance, while decreasing them reduces the index.

The formulation of the multiple linear regression model was carried out with EViews software, which allows us to identify the association of explained and explanatory variables, in order to identify which are the ones that best predict the index. It also allows us to rule out model errors —multicollinearity, heteroscedasticity, and autocorrelation— with relevant graphical and numerical tests.

Estimation models are important in performance evaluation contexts, since they help to improve municipalities' management results, anticipating possible outcomes. In the study, the indicators predict a significant relationship of 94.27%; consequently, a rational model is obtained good for estimating results.

An estimation model of municipal performance is presented, which provides tools to improve the results of municipal management through responsible budget management and the optimal use of municipal powers and attributions.

In this sense, the study suggests paying attention to the efficient application of spending by municipalities, because the model assumes a great burden on the fiscal capacity to cover local expenditures with their own revenues. Consequently, it is necessary to begin with a restructuring and analysis of municipal spending in order to mitigate the flypaper problem.

In addition, it allows linking the reports with financial incentives for municipalities with better performance and implementing strategies for municipalities with lower performance, through a follow-up and monitoring system in the variables of the forecast model.

In addition, the model determines the impact that a positive or negative variation of the predictor indicators has on the index, and therefore functions to implement actions to strengthen local public finances.

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