



The relation between property tax and municipal institutional capacities: The case of Hidalgo, Mexico

La relación entre impuesto predial y capacidades institucionales municipales: el caso de Hidalgo, México

José Francisco Martínez Sánchez^{*}, Alberto Cano Moreno

Universidad Autónoma del Estado de Hidalgo, México

Received January 1, 2021; accepted August 29, 2022
Available online November 14, 2023

Abstract

This study examined the association between institutional capacities and municipal income in Hidalgo, Mexico. Using (A) principal component analysis and (B) cluster analysis, the study analyzed variables related to municipal finance, institutional capacities, and public services. Results indicate that: (A) of the institutional capacities examined, budgeting, management, and implementation of public policies was most associated with the municipal income; (B) the municipalities of Hidalgo were grouped into three different clusters based on their institutional capacities and resources from federal transfers. Results emphasize that municipal public finance in Hidalgo is dependent on federal transfers; these results also contribute to a better understanding of the role of institutional capacities in the municipal income. To strengthen the public finances of the municipalities under their charge, decision-makers could consider more flexible mechanisms that streamline administrative processes and procedures.

JEL Code: D63, G18, H53, H68, H72, I32

Keywords: institutional capacity; federal transfers; municipalities; Hidalgo

^{*} Corresponding author.

E-mail address: jmartinez@uaeh.edu.mx (J. F. Martínez Sánchez).

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

<http://dx.doi.org/10.22201/fca.24488410e.2022.3184>

0186- 1042/©2019 Universidad Nacional Autónoma de México, Facultad de Contaduría y Administración. This is an open access article under the CC BY-NC-SA (<https://creativecommons.org/licenses/by-nc-sa/4.0/>)

Resumen

Esta investigación examinó la relación entre capacidades institucionales e ingresos municipales en Hidalgo, México. A través de los análisis de (A) componentes principales y (B) conglomerados, el estudio analizó variables financieras, de capacidad institucional y de servicios públicos. Los resultados indicaron que: (A) la presupuestación, gestión e implementación de políticas públicas fue la capacidad institucional mayormente asociada con los ingresos públicos; (B) los municipios hidalguenses se agruparon en tres distintos sectores, según sus capacidades institucionales y recursos por transferencias federales. Los resultados enfatizan que la hacienda pública municipal en Hidalgo es dependiente de las transferencias federales; los resultados también contribuyen a un mejor entendimiento del papel de las capacidades institucionales en los ingresos municipales. Para fortalecer las finanzas públicas de los ayuntamientos a su cargo, los tomadores de decisiones podrían considerar mecanismos o procedimientos más flexibles que agilicen procesos y procedimientos administrativos.

Código JEL: H27, H53, H71, H72, K34

Palabras clave: capacidades institucionales; transferencias federales; municipios; Hidalgo

Introduction

In Mexican municipalities, the development of institutional capacities is a key factor in the increase or use of public resources required to improve the provision of public goods and services (Cabrero, 2006). It is of little use for municipalities to have their own tax base if their "operation" is insufficient and the management of existing resources is deficient (Romo de Vivar & Gómez, 2016, p. 156). The "success" of fiscal federalism—i.e., a form of intergovernmental organization that controls the proportion of resources available to each level of government (Trujillo, 2008)—depends mainly on two factors: the generation of its own revenues and efficient spending on public goods and services (Romo de Vivar & Gómez, 2016). If it is considered that property tax is the main source of revenues at the local level (Canavire & Zúñiga, 2015), collected mainly to provide public services, the institutional capacity of municipalities is crucial for efficient collection (Romo de Vivar & Gómez, 2016).

In recent decades, the dependence of local public administrations on the federal transfer system—i.e., a system that allows municipalities to be part of the federal tax collection (Chigüil, 2014)—has suffered a setback in the institutional capacity to improve public finances (Arroyo & Guzmán, 2008). Previous studies have documented in Mexican municipalities an increase in their dependence on federal transfers, rising, for example, from 79% financial dependence in 1990 to 88% in 2010 (Bueno et al., 2017). These increases, nevertheless, have not been accompanied by increases in municipal revenues; the percentage of municipal revenues has even decreased from 13% to 4% in municipalities with a "very high" degree of marginalization and from 44% to 31% in municipalities with a "very low" degree of marginalization, from 1990 to 2010 (Bueno et al., 2017).

Furthermore, previous studies have identified Hidalgo as one of the states with the lowest compliance in generating its own revenues, such as property tax (IMCO, 2018). In 2018, for example, Hidalgo had federal transfers as its main source of revenue, representing 88% of the total revenue of this state; in turn, the percentage of its own revenue was only 10% (Congreso del Estado Libre y Soberano de Hidalgo, 2018). The above is worrisome since federal entities with a low capacity to generate their own revenues are less able to allocate a larger budget to the needs demanded by the population, such as the provision of public services (Bonet & Fretes, 2013).

Therefore, this study aims to analyze the relation between local treasury resources—particularly federal transfers and property tax—and some institutional capacities of municipalities in Hidalgo, such as administrative development, diagnosing public problems, formulating public policies and municipal strategies, budgeting, and implementing municipal policies. The study suggests that Hidalgo's municipalities are grouped according to their institutional capacities and the resources comprising their public finances. Characterizing these groups of municipalities is important as this could help to identify which institutional capacities represent areas of opportunity to improve the performance of local governments in terms of revenue collection.

This paper is organized as follows: it proceeds with a review of the literature, mentioning previous studies that analyze the phenomenon of fiscal decentralization and the determinants that influence the collection of property tax. Afterwards, the methodological aspects are established, i.e., sources of information, description of the variables used, and the statistical analyses employed (principal component analysis and cluster analysis). Next, the results obtained are presented, followed by a discussion of the results. Finally, the limitations of the research and the conclusions it was possible to reach are pointed out.

Review of the literature

The public finances available to municipalities primarily comprise resources from patrimonial assets, contributions on real estate property, rights derived from the provision of public services, and resources transferred by the federation (Auditoría Superior de la Federación, 2015). The legal nature of the municipality in Mexico, on the one hand, establishes it as the first level of government political organization that is most aware of the needs of citizens due to its proximity to them; on the other hand, it also places it as the most limited government body in terms of economic resources (Otero, 2011). The budgetary limitations that prevail in the municipality are a function of its inability to legislate in various areas, including revenue (Cabrera, Gutiérrez & Antonio, 2005).

Local governments are requesting a greater allocation of fiscal competencies to mitigate the federation's high concentration of tax resources (Aguilar, 2010). Nonetheless, this decentralization also represents a great challenge in terms of institutional capacities to improve the administration of local governments (Jaramillo, 2010). Fiscal decentralization establishes that the power of decision-making and fiscal or administrative responsibility in public administration is a process that starts from the federal government and spreads to other levels of government (Trujillo, 2008). In the face of a centralist design such as Mexico's—where the collection of the main tax resources is in the hands of the federation—municipalities are responsible for their own development through the design of projects and programs that increase their local revenues (Taguenca & León, 2011). For Cabrero (2006), centralism has led to neglecting the conditions in which subnational entities operate, specifically concerning policies that strengthen local institutional capacities.

In Mexico, several authors have analyzed the fiscal decentralization of municipal governments and the relation between property tax and federal transfers. For example, according to Canavire and Zuñiga (2015), there is not enough activity in local governments to efficiently apply the regulations that govern real estate taxation; this causes dependence on federal transfers and contributes to wasting resources that are the product of their own tax base. Mendoza (2019), on the other hand, postulates that decentralization does not seem to stimulate fiscal autonomy, as his results suggest an association between collection inefficiency and greater collection of federal transfers, especially in those sectors with greater economic development. Similarly, other authors (Unda & Moreno, 2014) have analyzed separately federal transfers, federal participations (unconditional transfers), and federal contributions (conditional transfers). These analyses show a marked municipal financial dependence on federal government resources, especially federal contributions (Espinosa Martínez & Martell, 2018; Carmona & Caamal, 2018; Sobarzo Fimbres, 2008; Sour, 2016).

Studies with emphasis on different sectors and contexts that study the financial dependence of municipalities on federal resources, not only with economic variables, are also worth mentioning. For example, the studies by Unda & Moreno (2015, p. 66) help to understand that there is indeed a "harmful" effect on municipal revenue collection as a result of federal transfers and that this effect is present in territorial units with similar economic conditions and regardless of the level of federal transfers that each one receives. Therefore, the discussion on fiscal decentralization should not be limited to economic/financial terms but should also include other issues or variables, such as the institutional capacities of subnational governments (Cabrero, 2006).

Municipalities' insufficient institutional capacities have affected local administrations' management and their results in promoting municipal development (Auditoría Superior de la Federación, 2015). Increasing municipalities' administrative and institutional capacities represents a key public policy

to develop a federalism that combats differences between territories and helps strengthen municipal autonomy (Aguilar, 1996). In other words, strengthening these capacities implies moving from fiscal federalism of direct transfers to fiscal or cooperative federalism concerned with the administrative and institutional municipal capacities (Gallardo, 2017).

For Romo de Vivar and Gómez (2016), the functioning of fiscal decentralization depends largely on strengthening the institutional capacities of municipalities, so it is necessary to study and analyze them as a whole. Cabrero (2006) adds a key factor for the purposes of this research: knowing the state of institutional capacities at the different local levels is decisive for measuring the progress of decentralization and, consequently, for identifying the approach required by each territory. Finally, Orozco, Huerta, and López (2018) conclude that the institutional capacities of municipalities are closely related to the nature of each municipality. Their status as rural or urban municipalities is a key factor in their development and, consequently, in generating their own revenues (Orozco et al., 2018).

Nonetheless, the literature on the institutional capacities of municipal governments in relation to federal transfers is scarce. Thus, this study analyzes the relation between federal transfers (federal participations and contributions), property tax (per capita), and various institutional capacities (administrative capacity, capacity to diagnose public problems, capacity to formulate public policies and municipal strategies, and capacity to budget and implement such policies) of the municipalities of the State of Hidalgo, Mexico. The study seeks to contribute to a better understanding of the relation between local institutional capacities and the resources received by municipalities through federal transfers. The purpose is to help understand the mechanisms that strengthen local public finances through generating their own revenues and through better management of existing resources, using the case of Hidalgo, Mexico.

Methodology

Information sources and databases

The present study used a cross-sectional design based on an analysis of existing data from different sources. Data from the 84 municipalities of the state of Hidalgo, Mexico, were compiled for representative indicators of institutional capacities and local public finance revenues, with emphasis on resources from the federation (federal contributions and federal participations). The most current data were considered, collected by: Budget Transparency of the Ministry of Finance and Public Credit; the Superior Audit Office of the Federation (Diagnosis of Municipal Institutional Development, 2015); and the United Nations Development Program (Municipal Human Development Report, 2019).

In accordance with the conceptual framework of this study, the following eight variables were selected: federal participations; federal contributions; per capita property tax; diagnosis of municipal problems; formulation of municipal public policies and strategies; budgeting, management, and implementation of municipal policies; administrative development index; and coverage ratio in the provision of public services. The description of each variable is presented in Table 1.

Table 1
 Name and description of the variables used in this study for the 84 municipalities of Hidalgo

Variable	Description
Federal contributions [†]	Amount of federal contributions in 2018, in current Mexican pesos.
Diagnosis of municipal problems [§]	Definition: Assesses the ability to generate valuable information on municipal management, the local economy, demographics, and the environment, as well as the conduct of strategic planning (having an institutional mission and vision)**. Measuring components: Ability to obtain, collect, and disaggregate data related to a public problem; ability to analyze data and information; and ability to convert data and information into a vision or mandate**. Range: 0.0 - 1.0.
Formulation of policies and strategies for municipal problems	Definition: Synthesizes the existence of plans for municipal development, urban development, economic development, environmental programs, improvement of public services, and policies to comply with these plans**. Measuring components: ability to consider and analyze different solution options for each public problem; ability to set objectives; ability to develop sectoral and cross-cutting policies; and ability to manage mechanisms to establish priorities**. Range: 0.0 - 1.0.
Administrative development index [¶]	Evaluates the administrative capacities of the municipalities Range: 0.0 - 1.0
Federal participations [†]	Amount of federal participations in 2018, in current Mexican pesos.
Municipal budgeting, management, and policy implementation [§]	Definition: Covers variables that make it possible to assess the capacity to manage economic resources before other entities, as well as the existence of social comptrollership, accounting harmonization, rationality programs, training of public officials, introduction of improvement plans, and auditing**. Measuring components: ability to formulate, plan, manage, and implement projects and programs, including the preparation of a budget; ability to assess their capacity to manage human resources; ability to incorporate indicators for monitoring; and follow-up of progress**. Range: 0.0 - 1.0.
Property tax collections per capita [†]	Amount of property tax per capita in 2019, in current Mexican pesos.
Coverage ratio in the provision of public services [¶]	Municipal capacity to comply with the functions that correspond to it in the provision of public services in accordance with Article 115 of the Constitution**.

Notes: Data obtained from: † Transparencia Presupuestaria, Observatorio de Gasto de la Secretaría de Hacienda y Crédito Público, <https://www.transparenciapresupuestaria.gob.mx/>; § Informe de Desarrollo Humano Municipal 2019, www.mx.undp.org; and ¶ Diagnóstico del Desarrollo Institucional Municipal 2015, www.asf.gob.mx/Trans/Informes/IR2018c/Documentos/Auditorias. ** (Huerta & Vanegas, 2020). Source: created by the authors

Statistical analysis

Machine learning algorithms that employ mathematical theory and computation were used to find relations and patterns in information bases that may or may not be structured. The study used the principal component analysis technique to determine the most representative variables, as well as cluster analysis using the k-means method to find groups (clusters) of municipalities with similar characteristics within the group and different from those of other groups.

Descriptive statistics and correlation analysis

Different statistical indicators were calculated, such as means, standard deviation, correlation coefficient, and quantiles at 95% and 98%, to identify outliers. To avoid information bias due to the different nature of the variables used, the variables under study were standardized to have a mean of zero and a standard deviation of one. Pearson's correlation coefficient was used to study the relationship between two variables.

Principal components analysis (PCA)

PCA has been used both to reduce the dimensionality of the data and to help classify the data (Ding & He, 2004). Each principal component represents the linear combination of the original variables that capture the most variance in the data (Lever et al., 2017), and the coefficient (or loading) of each component represents the correlation between each of the eight variables and the component in question. The use of PCA makes it possible to "synthesize" and structure the information provided by the data (Lozares Colina & López-Roldán, 1991, p. 33). In other words, PCA makes it possible to summarize, in principal components, all the information captured by the eight variables (Bandyopadhyay et al., 2020) to classify or group this information meaningfully.

Cluster analysis

Once the municipalities were represented on the map in terms of their principal components, the cluster analysis method was used to identify groups (or clusters) of municipalities that were similar (Tan, Steinbach, Karpatne, & Kumar, 2018), based on the information provided by the financial/monetary, administrative, and institutional capacity variables. Cluster analysis seeks to ensure that observations (i.e., municipalities) classified in the same group are similar to each other but different from observations classified in other groups (Tan et al., 2018). A partitional (non-hierarchical) classification method was used for the cluster analysis to classify the observations into mutually exclusive groups and not into subgroups (Tan et al., 2018). Since the data used are of a continuous nature, the k-means method was used for the classification of municipalities. The k-means algorithm classifies the observations into a predetermined number of groups represented by the centroid—the most central point—of each group (Tan et al., 2018).

The number of clusters was selected based on the "elbow method." According to this method, the number of groups or clusters is plotted versus the variance within each sector (Nanjundan et al., 2019). After a certain number of clusters, each additional cluster will provide less information; graphically, the point at which the addition of additional clusters represents or provides less information is observed by an inflection point or an "elbow" (Nanjundan et al., 2019). Rather than simply assuming that observations can be clustered, the present analysis also examined how well they can be clustered using the Hopkins statistic. When the value of the Hopkins statistic is greater than 0.5, and in ideal cases very close to 1.0, the clustered data are "very well defined" (Banerjee & Davé, 2004, p. 150). The analyses were performed with Python on Google's Colaboratory platform.

Results

Descriptive statistics

Table 2 presents descriptive statistics of the variables used in this study for the 84 municipalities of Hidalgo, while Table 3 presents the correlation coefficients between pairs of variables. Differences were observed between municipalities concerning the rank of each variable. For example, while one municipality reported 11.6 million pesos in federal contributions, another municipality reported 335 million pesos in federal contributions. The marked differences between minimum and maximum values for each variable extended to federal participations, per capita property tax, and the remaining variables.

Univariate analysis (e.g., box plot not shown here) revealed the presence of outliers for federal transfers and federal participations, property tax per capita, and the administrative development index. Values above the 99th percentile were truncated for subsequent analyses in accordance with previous studies (Polanco, 2016), thus reducing the number of municipalities to 78 for multivariate analyses (which represented 92.9% of retained data).

Table 2
 Descriptive statistics of the variables used in the study for the 84 municipalities of Hidalgo

Variable	Mean	Standard deviation	Minimum Value	Maximum Value
Federal contributions, in millions	63.20	52.80	11.60	335.00
Problem diagnosis	0.11	0.12	0.00	0.60
Policy and strategy formulation	0.53	0.34	0.00	1.00
Administrative development index	0.47	0.10	0.27	0.81
Federal participations, in millions of pesos	50.10	38.10	23.10	324.00
Budget, management, and policy implementation	0.36	0.16	0.07	0.89
Per capita property tax	177.26	334.62	8.00	2818.00
Coverage ratio, provision of public services	0.79	0.15	0.36	1.00

Notes: Data obtained from: Transparencia Presupuestaria, Observatorio de Gasto de la Secretaría de Hacienda y Crédito Público; Informe de Desarrollo Humano Municipal, 2019; and Diagnóstico del Desarrollo Institucional Municipal, 2015.

Source: created by the authors

Table 3
 Correlation coefficients between pairs of variables in the study for the 84 municipalities of Hidalgo

	1.	2.	3.	4.	5.	6.	7.	8.
1. Federal contributions	—							
2. Problem diagnosis	0.10	—						
3. Policy and strategy formulation	-0.01	0.35**	—					
4. Administrative development index	0.15	0.14	0.11	—				
5. Federal participations	0.75***	0.13	0.01	0.25*	—			
6. Budget, management, policy implementation	0.30**	-0.03	-0.01	0.06	0.44***	—		
7. Per capita property tax	-0.01	0.00	0.05	0.00	0.13	0.01	—	
8. Coverage ratio, provision of public services	0.07	-0.07	-0.11	0.01	0.19	0.25*	0.31**	—

Notes: *p < .05. **p < .01. ***p < .00. Data obtained from: Transparencia Presupuestaria, Observatorio de gasto de la Secretaría de Hacienda y Crédito Público; Informe de Desarrollo Humano Municipal, 2019; and Diagnóstico del Desarrollo Institucional Municipal, 2015.

Source: created by the authors

Property tax per capita and federal transfers in Hidalgo

Figure 1 helps to understand the relation between federal transfers and per capita property tax in Hidalgo, Mexico. Even though the correlation between variables (transfers and property tax) is low ($r = -0.32$, $p < 0.01$), it is observed that the higher the amount of federal resources, the lower the property tax per capita. That is to say, in the hypothetical case that federal resources were allocated directly to each inhabitant of the municipality, it would seem that the greater the amount of federal resources received by each person, the less would be collected in property tax from them. This would seem to generate a "harmful" effect among the inhabitants when contributing to public spending due to such federal transfers.

It is possible that several capabilities, such as the capacity to budget, manage, and implement public policies or projects, positively affect the property tax. In the correlation analysis, positive associations were found between the property tax and the index of functional capacities ($r = 0.22$, $p < 0.05$) and the capacity to implement ($r = 0.30$, $p < 0.01$). For example: Tepeapulco, marked with circle number 61, reported 56% of capacity to budget, manage, and implement public policies or projects; Atitalaquia, circle number 10 in the graph, reported 40% of such capacity; and Mineral de la Reforma, circle number 51, reported 70% of the same capacity. In contrast, municipalities with very high levels of transfers (e.g., Pacula, Juárez Hidalgo, and Eloxochitlán, represented in Figure 1 by circles 47, 33, and 20, respectively) reported very low levels of property tax per capita.

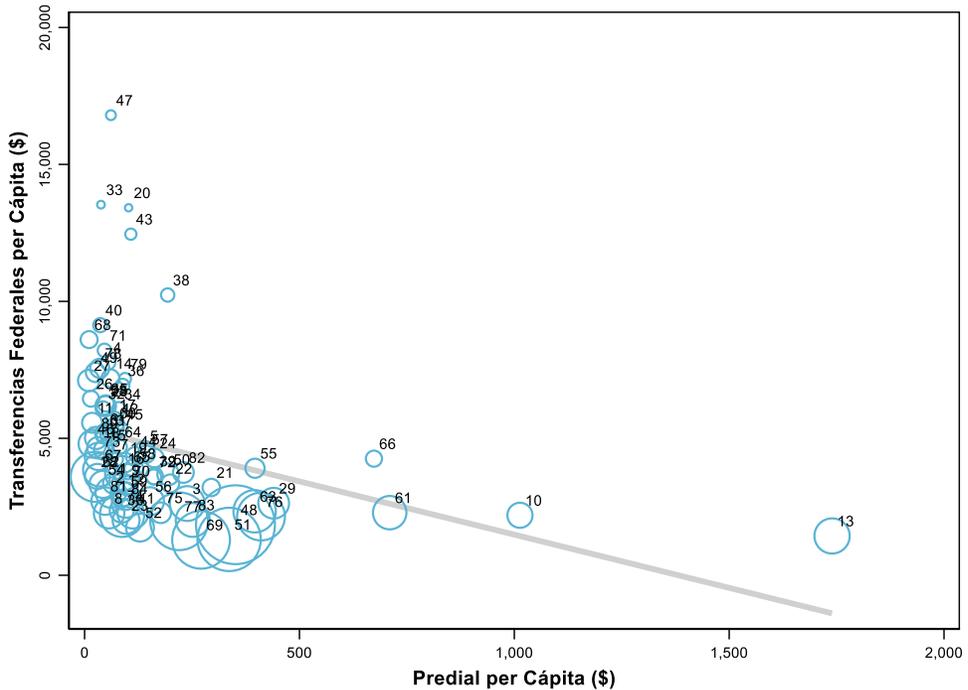


Figure 1. Federal transfers per capita and property tax collected per capita, Hidalgo, Mexico (n=84)
Notes: "Property tax per capita" in the x-axis and "federal transfers per capita" in the y-axis. Each circle represents a municipality in Hidalgo. The gray line indicates the simple linear regression of property tax per capita on federal transfers. The two digits next to each circle identify each municipality, and the size of the circle denotes its number of inhabitants. The numbers next to each circle correspond to the last two digits of each municipality's national code; for example, Atitalaquia is represented by "10" since its municipal code is 13010.

Source: created by the authors

Principal components analysis (PCA)

Based on the three financial/monetary variables and the five administrative or institutional capacity variables, the principal components analysis indicated that one component explained approximately 47% of the total variance in the set of variables, while two components explained more than 60% of this variance (Appendix, Figure A1). Although each additional component increased the percentage of total variance explained, for the sake of parsimony, only the first two components will be considered. By examining the covariance matrix, it was observed that the principal components were not related to each other since the highest and lowest correlations between components were 0.005 and -0.002, respectively (i.e., being very close to zero, these correlation indices indicate that the components are not related to each

other). This is significant because the principal components, by definition, are orthogonal; therefore, their correlation is very close to zero (Appendix, Figure A2).

Table 4 shows the matrix of coefficients representing the weight of each variable for each of the principal components (factor loadings), some greater than 0.30, and few coefficients in the inverse (negative) direction; the model presents a good fit to the data. For the first component, the federal participations and federal contributions (i.e., federal transfers) variables show the highest positive and significant correlation of the total set of variables, with coefficients of 0.61 and 0.49, respectively. The variable "property tax per capita" also shows a positive and significant correlation (coefficient of 0.40). Finally, the variable "budget, management, and policy implementation" shows, although to a lesser extent, a positive and significant relationship (coefficient of 0.36). For this reason, this component 1 was named "government revenues."

Table 4
 Results of the principal component factor analysis (without rotation) for a two-factor solution

	Component 1 "Government revenues"	Component 2 "Professional Capabilities"
1. Federal contributions (aportfed)	0.49	0.23
2. Problem diagnosis (diagnosmun)	0.11	0.50
3. Policy and strategy formulation (estramun)	0.06	0.46
4. Administrative Development Index (idesadm)	0.08	0.40
5. Federal participations (partfed)	0.61	0.15
6. Budget, management, policy implementation (politmun)	0.36	-0.23
7. Property tax per capita (predpc)	0.40	-0.32
8. Coverage ratio, public service provision (servpub)	0.28	-0.38

Note: Figures in bold indicate factor loadings with higher weights on a certain factor and loadings greater than 0.30 on the factor. The name of each variable is placed in parentheses. Variable names (e.g., "aportfed") are added to allow their identification in Figure 2.

Source: created by the authors using Python on Google's Colaboratory platform

The second component is most notably related to the capacity to diagnose public problems, to the formulation of strategies and public policies, and to the administrative development index, with coefficients of 0.50, 0.46, and 0.40, respectively. To a lesser degree, the second component is also related to the coverage ratio in the provision of public services (coefficient of -0.38). This second component is called "professional capabilities." The results for the two-component solution are shown in Figure 2, where the degree of proximity between each variable and each component indicates the degree of relation between them.

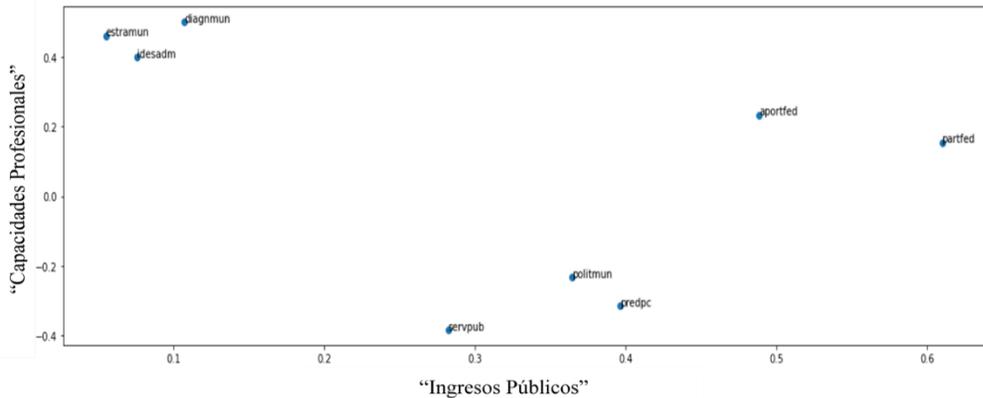


Figure 2. Principal Components: "Government Revenues" and "Professional Capabilities"

Note: The description and name of each variable are available in Table 4.

Source: created by the authors using Python on Google's Colaboratory platform

It should be mentioned that the selection of principal components sought to maximize the variance explained with the smallest possible number of components. Therefore, only the first two principal components were considered, represented two-dimensionally, and accounted for 62% of the variance. The first component, "government revenues," includes one of the local revenues: the property tax. The weight of the property tax (0.40) is only below the weight corresponding to federal transfers (0.61 of federal participations and 0.49 of federal contributions, respectively). In other words, this component, "government revenues," is mainly determined by federal resources and, secondarily, by the property tax, hence its relation with the principal components. Concretely, the results for the state of Hidalgo seem to coincide with the results of studies at the national level: in Hidalgo, federal transfers constitute the main source of resources for the local treasury. However, beyond this, the results of the present study clarify the complex relation between federal transfers and institutional capacities for Hidalgo's municipalities. The first component helps to identify which municipalities in Hidalgo are more dependent on federal transfers and for which the "exploitation" of their tax base does not seem to be a priority. The above helps to characterize the profile of municipalities in Hidalgo based on their "tax collection."

Cluster analysis

Before classifying the municipalities into clusters, the Hopkins statistic yielded a value of 0.70, indicating that the data are viable for clustering (Banerjee & Davé, 2004). The "elbow" figure (Appendix, Figure A1) subsequently indicated that the number of groups or clusters to be chosen should be three. The cluster analysis results are presented in Figure 3 ("cluster dispersion for three groups or clusters").

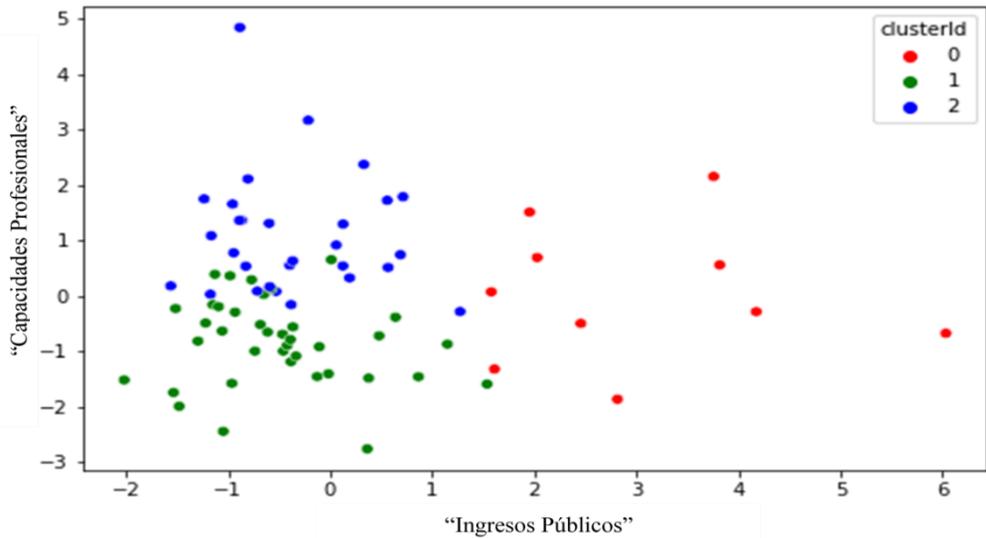


Figure 3. Cluster scatter plot for three groups or clusters (k=3)

Note: Abbreviations: k, number of groups; clusterid, group number; PC, principal component.

Source: created by the authors using Python on Google's Colaboratory platform

In Figure 3, each point represents a municipality (whose place in the figure is based on the information provided by the principal components) and is displayed in a different color based on the group to which it belongs. The municipalities in red (i.e., group 0) comprise the smallest group, with 10 municipalities. Group 0, named "higher federal transfers and generally low institutional capacity," has a profile more oriented toward federal transfers (federal participations and federal contributions). Moreover, the largest group, the group in green (i.e., group 1), with 39 municipalities, is the relatively more vulnerable group, as it has a profile less oriented to federal participations and federal contributions and is not characterized by high institutional capacities; this group is named "fewer federal resources and low institutional capacity." Lastly, the group in blue (i.e., group 2), with 29 municipalities, is characterized by

having a more targeted orientation to institutional capacities, capacities to formulate strategies and public policies, capacities to diagnose municipal problems, and administrative development capacities. The name assigned to this group is "better institutional capacities and low uptake of federal transfers."

Discussion

This study examined the relation between federal transfers, the property tax, and various institutional capacities of Hidalgo's municipal public administrations. The purpose was to better understand the degree to which these institutional capacities are affected or benefited by both a change in resources from the federation and each municipality's tax base. The results of the study indicated that "government revenues," mostly represented by the first principal component, are related to two monetary variables: federal participations and federal contributions. Through "government revenues," there is a greater incidence of federal transfers on municipal finances than could be represented by property tax per capita.

The main sources of revenue for municipal administrations are made up of federal participations and federal contributions, and property tax revenues (Carmona, 2018). Previous studies have analyzed the role played by federal transfers in municipal public finances with respect to property tax collection, mainly considering economic variables. For the case of the Hidalgo municipalities, the results of the present study coincide with previous studies conducted in other contexts and regions (Cantú, 2016). In terms of "government revenues" (i.e., first component) and "professional capacities" (i.e., second component), the results of the present analysis suggest that Hidalgo municipalities with more "government revenues" are those that obtain more resources from federal transfers. On the contrary, municipalities with less "government revenues" seem to "do less well" in receiving federal resources. That is, the amount that municipalities receive in federal transfers and what they collect in their own revenues (including property tax) is so unequal that it somehow justifies the passivity or inaction of the municipalities in auditing their own revenues.

Previous research, such as that of Moreno (2007), has reported the negative effect of federal transfers on municipalities' own revenue collection. Such transfers are necessary for local public finances in light of the loss of municipal financial autonomy resulting from the current fiscal design. Nevertheless, if the success of fiscal decentralization is sought to positively impact municipal finances by raising more of their own revenues, it is necessary to go beyond the study and analysis of economic variables (Cabrero, 2006). Being self-sufficient in generating their own resources is fundamental for municipalities to move toward greater fiscal decentralization, and to achieve this, the role of municipalities' institutional capacities is critical. In addition, strengthening these institutional capacities would suggest a more efficient management of the resources already existing in municipal public finances.

It is therefore necessary to incorporate another type of variable into the analysis of the financial dependence of local governments and their relation to federal resources. This refers to the institutional capacities of the municipalities. The results of the study show indeed that "professional capacities" are determined by municipal institutional capacities—the capacity to identify public problems, and to formulate strategies and public policies—and by the capacity for administrative development. The municipalities with a higher level of "professional capacities" are those municipalities that differentiate or stand out from the rest because of their capacity to diagnose public problems, to formulate public policies and strategies, and their capacity for administrative development. Conversely, municipalities with less "professional capabilities" have more deficiencies in diagnosing public problems, formulating public policies and strategies, and in their capacity for administrative development.

Based on the level of "government revenues" received by the municipalities and their "professional capacities," the present study also sought to identify the general "profile" of the municipalities, classifying them into groups or clusters by characteristics similar to one another, but different from others grouped in other sectors. Three groups of municipalities were identified. The first group (cluster 0 with 10 municipalities) represents municipalities with "higher federal transfers and generally low institutional capacity." Property tax is the other characteristic variable of this group, although in a less significant way. This somewhat corroborates what has been written in previous studies and reports on municipal finances: property tax generally represents the second source of revenue for local treasuries (Villegas, 2017).

Despite the above, the group with "higher federal transfers and generally low institutional capacity" (group 0) seems to have certain vulnerabilities. Their deficient capacity to identify public problems, to formulate public policies, and to develop their administrative capacity would place them in a situation of "risk" in the face of a possible eventuality such as a decrease in federal resources. Furthermore, it puts at risk the efficient management of financial resources already existing in the local public treasury. However, their capacity to budget, manage, and implement municipal policies is high. This suggests that one of the strengths of this sector, in addition to its greater federal resources, is its effectiveness in implementing municipal projects and programs. Consequently, this capacity to manage the budget, human resources, and procurement of municipal programs and projects is positively reflected in the coverage of public services. For many municipalities, identifying, diagnosing, and formulating strategies and public policies is complicated, but their implementation is more complicated, i.e., managing and obtaining the economic and human resources to put into practice what is set down in writing.

Group 0 includes the capital city of Hidalgo, Pachuca de Soto, as well as the most populated and industrialized municipalities of the state (e.g., Atotonilco de Tula, Tula de Allende, Mineral de la Reforma, and Tizayuca). If the Fiscal Coordination Law (LCF) (Spanish: Ley de Coordinación Fiscal)

establishes different criteria for transferring federal resources to each local government, these governments seem to be "benefited" by said Law without necessarily prioritizing their fiscal effort. In other words, they seem to take advantage of their territory's size or number of inhabitants (among others) to receive significant amounts of federal resources. Nonetheless, it is worth noting that a higher level of institutional capacities of these municipalities is not reflected in a higher level of property tax per capita collection, which seems to result in a lower investment in public services.

The second group (group 1 with 39 municipalities) represents municipalities with "fewer federal resources and low institutional capacity." Municipalities in this group seem to have much "against them" regarding few federal resources and low institutional capacities. It is appropriate to reflect on two important aspects for this group: The distribution of federal transfers is made based on certain formulas established in the LCF (*Ley de Coordinación Fiscal*, last reform published in the *Diario Oficial de la Federación* 30-01-2018) and under certain criteria. There are very small and rural municipalities that do not have the administrative conditions to carry out their governmental activity. Bearing in mind these two aspects, if the very condition of the municipalities of this group makes them receive few resources, it would in a certain way "justify" their position in this sector and, therefore, suggest the establishment of a policy that would allow them to lessen their low levels of federal resources and institutional capacities. The fact is that there are municipalities with few inhabitants, mostly rural localities, and high poverty rates, among other factors, which make it difficult to comply with many of the criteria considered in the LCF formulas for the distribution of federal and state resources.

If, on the contrary, municipalities with the necessary conditions to be recipients of greater federal resources or to improve their institutional capacity were concentrated, it would be assumed that the lack of political and administrative will is one of the possible causes of their current condition. Group 1 includes localities such as Huehuetla, a municipality identified as being in a situation of "extreme poverty." By law, municipalities in extreme poverty must receive additional federal resources such as those from the Social Infrastructure Contributions Fund (FAIS). Nevertheless, the extent to which these municipalities receive such resources is unclear, given their high level of extreme poverty. With little or no capacity to contribute to government spending, the municipality's "opportunity" to obtain more capital and use it for social benefit seems limited.

Finally, the third group (group 2 with 29 municipalities) was characterized by having "better institutional capacities and low uptake of federal transfers." The results for this group would imply that as municipalities with better institutional capacities, they could better face possible adversities, and above all improve their own revenue collection. The situation of this group, which receives few federal resources, makes it necessary and to a certain extent "urgent" to implement this greater institutional capacity to open up the possibility of having greater local resources. Nonetheless, it is important to remember that a

government with better institutional capacities does not necessarily use them for municipal development (United Nations Development Program in Mexico, 2019). Therefore, it is necessary to investigate those factors that could be causing the underutilization of this government capacity.

Another characteristic of group 2 ("high federal transfers and generally low institutional capacity") is its marked heterogeneity (i.e., the dispersion that exists among the ten municipalities that make up this group), mainly in terms of component 1, "government revenues." This seems to be the group where the development of institutional capacities is 50/50; that is, five municipalities seem to positively develop such capacities, as opposed to the remaining five (behavior of the municipalities with respect to component 2, "professional capacities"). When forming subgroups of group 2 (Appendix, Figure A3) to explore this marked heterogeneity, the following is observed: group 2 includes the municipalities of the state with the largest population and those with the greatest economic and industrial activity (i.e., Pachuca, Actopan, Huejutla de Reyes, Mineral de la Reforma, Tepeji del Rio de Ocampo, Tezontepec de Aldama, Tizayuca, Tulancingo, Tula de Allende, and Ixmiquilpan).

These municipalities include the capital of Hidalgo and the municipalities that contribute the most to the state's gross domestic product. In other words, it seems that these municipalities are distinguished from all the others by receiving a large amount of public money from the federation and by generating the largest amount of property tax collection. In this group (2) are municipalities such as Tianguistengo and Tepehuacán de Guerrero, among others, which, like the municipalities in the previous group (group 1), have a high level of extreme poverty. But unlike the municipalities in Group 1, the municipalities in Group 2 report high institutional capacities. In other words, the municipalities in the latter group have the lowest federal transfers and the highest institutional capacities. This suggests that the poverty of several municipalities is not necessarily a barrier to developing certain institutional capacities.

The municipalities in the third group ("better institutional capacities and low uptake of federal transfers") appear to have greater institutional capacities, specifically to diagnose public problems, to formulate strategies and public policies, and in their administrative development. Nevertheless, they have little capacity to budget, manage, and implement municipal policies and consequently, to satisfy the coverage of public services and collect resources from property taxes. The capacities to budget, manage, and implement public policies consist of implementing projects and programs, including budget preparation, management of human and financial resources, and the establishment of indicators to monitor progress (United Nations Development Program in Mexico, 2019). One way to evaluate the work of local government is the satisfaction of basic public services; if these are "good," it is considered that the policy, program, or project aimed at improving their quality and coverage was successful. In other words, it is the implementation of what may have started with a simple proposal, which is then worked on, and finally

made a reality for all citizens. It is of little use to have a well-structured, well-designed policy if it remains on paper, that is, if it is not implemented for the benefit of the people.

Limitations

One of the limitations of this study was the selection and inclusion of variables. Involving different private and social actors in the public policy process is important for generating and strengthening municipal institutional capacities; however, it was not possible to use these data since they are not available for all municipalities in Hidalgo. Nevertheless, other important variables were selected, which, from the public policy approach, provide relevant information for designing, implementing, and evaluating public policies, programs, and projects.

Another limitation of this study was the measurement of the administrative development index. For "municipal development plans," the indicator used is limited to considering their existence. However, it is known that in most cases, they are discursive documents, and their mere existence does not guarantee that their content contemplates the needs of the population or their efficient implementation. Similarly, the indicator "municipal regulations" is limited to the availability of municipal laws without considering reforms or additions to them. Finally, regarding the indicator "availability of land registry and its updating," it was not possible to access information on the value of rustic and urban property in each of the states of the republic, including Hidalgo, so this indicator lacks one of the main updating criteria. In addition to the above, there is no data available from 2015 to 2020, which would be useful since in that period there have been changes in municipal administrations, where the political factor is crucial in decision making.

Conclusions

As the results of this study indicate, several Mexican municipalities, including the municipalities of Hidalgo, present a high rate of financial dependence on federal resources (Moreno, 2017), which hinders the collection of their own revenues and harms the comprehensive development of their inhabitants (Aguilar, 2010). The results also emphasize that municipal public finances in Hidalgo are highly financed by federal transfers, while property tax constitutes a secondary source of revenue. Although this typical phenomenon of fiscal federalism in Mexico is common among subnational governments, the results of this study also contribute to a better understanding of the role of institutional capacities in generating their own revenues.

Decision makers could "strengthen" certain institutional capacities to improve public projects aimed at increasing the local tax base to strengthen their municipalities' public finances. In particular, the capacity to budget, manage, and implement municipal public policies seems to constitute an opportunity for greater municipal financial autonomy. One of the issues comprising the capacity to budget, manage, and implement public policies, and which would imply "strengthening" local tax collection, is the management of human resources. Creating an area or institution that coordinates the professionalization of public servants in charge of tax collection could be a good strategy to improve revenue collection.

As Mattar (2018) points out, it is possible to achieve better functioning of the local public administration through professionalizing the public service; in this case, greater collection of property taxes translates into better public services. Previous studies have shown that the lack of professionalization of the public service in federal entities is reflected in the deficient management of the accounting, land registry, collection, and administrative process control systems (Bolaños & Francos, 2021). In addition, through the professionalization of public servants, it is possible to monitor and follow up on the progress achieved in collection issues, among others, since the evaluation of public interventions requires certain capacities and technical skills (Mayorga, 2017). Systems for monitoring and evaluating progress provide relevant information to improve the "impact" of projects or public policies (Aquilino et al., 2018). By identifying advances and setbacks in the processes or forms of property tax collection—such as incentives for timely payment—collection modules or systems could modify or strengthen public policies aimed at increasing the collection of revenues (Cantú, 2016).

Those in charge of making and implementing public policy should identify some areas where more work is needed so that citizens can witness the municipal work and development in their communities. The results of this study made it possible to characterize the State of Hidalgo in terms of the economic resources available to the local treasury and its institutional capacities. Understanding how the municipalities of Hidalgo are grouped according to these variables enables decision makers to focus strategies or policies according to the needs of their municipalities.

References

- Aguilar Gutiérrez, G. (2010). Capacidad tributaria y finanzas públicas metropolitanas en México. *Estudios Demográficos y Urbanos*, 25(1), 103-132. <https://doi.org/10.24201/edu.v25i1.1369>
- Aquilino, N., Potenza, F., & Rubio, J. (2018). 10 decisiones para construir un sistema de monitoreo y evaluación de políticas públicas. *Academia. Accelerating the world's research. CIPPEC. Programa de Monitoreo y Evaluación*, 8(166), 11 -16.

- Arroyo Alejandro, J. & Guzmán Flores J. (2008). Capacidades institucionales en los municipios en la promoción económica local. *Carta Económica Regional*, 100, 7-30.
- Bandyopadhyay, S., Thakur, S. S., & Mandal, J. K. (2020). Product recommendation for e-commerce business by applying principal component analysis (PCA) and K-means clustering: Benefit for the society. *Innovations in Systems and Software Engineering*, 1-8. <https://doi.org/10.1007/s11334-020-00372-5>
- Banerjee, A., & Dave, R. N. (2004). Validating clusters using the Hopkins statistic. 2004 IEEE International conference on fuzzy systems (IEEE Cat. No. 04CH37542), 1, 149-153. <https://doi.org/10.1109/fuzzy.2004.1375706>
- Bolaños, R., & Franco, A. (2021). El impuesto predial: la oportunidad que todos dejan pasar. *Ethos*. <https://www.ethos.org.mx/wp-content/uploads/2021/02/Predial-2021-ISBN-comprimido.pdf>.
- Bonet, J. A., & Fretes Cibils, V. (2013). Más ingresos propios para más desarrollo local en Latinoamérica. II Jornadas Iberoamericanas de Financiación Local (La Plata, 2013).
- Bueno Cevada, L. E., Netzahuatl Méndez, M. F., & Sánchez Gómez, K. F. (2017). Dependencia financiera de las transferencias federales en los municipios de México. *Revista Global de Negocios*, 5(4), 13-25.
- Cabrera Adame. C. J., Gutiérrez Lara, A. A. & Antonio Miguel, R. (2005). Principales indicadores financieros y del sector externo de la economía mexicana. Universidad Nacional Autónoma de México.
- Cabrero Mendoza, E. (2006). Los retos institucionales de la descentralización fiscal en América Latina. (Disponible en: <http://repositoriodigital.cide.edu/bitstream/handle/11651/803/71157.pdf?sequence=1>) y (consultado: 05/11/2020).
- Canavire-Bacarreza, G. & Zúñiga Espinoza, N. G. (2015). Transferencias e impuesto predial en México. *Economía UNAM*, 12(35), 69-99. <https://doi.org/10.1016/j.eunam.2015.09.004>
- Cantú Suárez N. E. (2016). Determinantes en la recaudación del impuesto predial: Nuevo León, México. *Innovaciones de Negocios*, 13(26), 166-190. <https://doi.org/10.29105/rinn13.26-2>
- Carmona Guerrero, N., & Caamal-Olvera, C. G. (2018). ¿Las transferencias federales han logrado reducir la desigualdad en las entidades federativas en México? *EconoQuantum*, 15(1), 31- 51. <https://doi.org/10.18381/eq.v15i1.7110>
- Chacón, B. (2017). Diagnóstico de las capacidades institucionales de los municipios mexicanos en materia de evaluación de políticas públicas. (Disponible en: <http://frph.org.mx/bdigital/verpdf.php?cve=abc275-04>) y (consultado 28/09/2020).

- Cruz Meléndez, C. A. (2010). Aportes del desarrollo organizacional a la administración pública municipal. Encrucijada, Revista Electrónica del Centro de Estudios en Administración Pública, 4, 1-13. <https://doi.org/10.22201/fcpys.20071949e.2010.4.58524>
- De la Federación, A. S. (2015). Diagnóstico del desarrollo institucional municipal. México: Auditoría Superior de la Federación. (Disponible en: <http://200.23.8.25/ASF/descarga/resultados/Hidalgo.pdf>) y (consultado: 11/09/2020).
- CONEVAL, C. (2020). Informe de Pobreza y evaluación 2020. Hidalgo. (Disponible en: https://www.coneval.org.mx/coordinacion/entidades/Documents/Informes_de_pobreza_y_evaluacion_2020_Documentos/Informe_Hidalgo_2020.pdf) y (Consultado: 30/09/2020).
- Congreso del Estado Libre y Soberano del estado de Hidalgo (2018). Iniciativa de Ley de ingresos para el ejercicio fiscal 2019. Mesa Directiva del Honorable Congreso del Estado libre y Soberano de Hidalgo. (Disponible en: <http://sistemaanticorrupcion.hidalgo.gob.mx/pdf/TitQuinto2019/IniciativaDeIngresos.pdf>) y (Consultado: 10/10/2020).
- Ding, C., & He, X. (2004). K-means clustering via principal component analysis. Proceedings of the twenty-first international conference on Machine learning (ICML '04). Association for Computing Machinery, New York, NY, USA. <https://doi.org/10.1145/1015330.1015408>
- Espinosa, S., Martínez, J., & Martell, C. (2018). ¿Por qué algunos municipios en México son mejores recaudadores de impuesto predial que otros? *Gestión y política pública*, 27(2), 375-395.
- Fernández-Segado, F. (2003). El federalismo en América latina. *VRÜ Verfassung und Recht in Übersee*, 36(1), 23-48. <https://doi.org/10.5771/0506-7286-2003-1-23>
- Gallardo García, M. M. (2017). El desequilibrio fiscal en el federalismo mexicano: La capacidad tributaria del municipio. Universidad Juárez del Estado de Durango. (Disponible en <http://investigacionesjuridicas.ujed.mx/includes/docs/desequilibriofiscal.pdf>) y (Consultado: 19/10/2020).
- Gaona Montiel, F. & Mendoza Pérez, J. (2019). Estructura fiscal y descentralización en México: Un análisis institucional con énfasis en la disfuncionalidad en el uso de recursos de los Estados, 2016. *Denarius*, 36, 165-165. <https://doi.org/10.24275/uam/izt/dcsh/denarius/v2019n36/gaona>
- Huerta Cuervo, R., & Vanegas López, M. (2020). Metodología para la construcción del Índice de Capacidades Institucionales Municipales (icim). *Sobre México. Temas de Economía*. 1(2), 101-133.
- Jaramillo Cardona, M. C. (2010). La descentralización: Una mirada desde las políticas públicas y las relaciones intergubernamentales en Baja California. *Región y Sociedad*, 22(49), 177-200. <https://doi.org/10.22198/rys.2010.49.a426>

- Instituto Mexicano de la Competitividad. (2018, octubre 11). Índice de información del ejercicio del gasto 2018. Presupuestos estatales: Simulación y discrecionalidad. (Disponible en: <https://imco.org.mx/indice-informacion-del-ejercicio-del-gasto-2018/>) y (consultado: 20/10/2020).
- Lozares Colina, C., & López-Roldán, P. (1991). El análisis de componentes principales: Aplicación al análisis de datos secundarios. *Papers: Revista de Sociología*, 37, 031-63. <https://doi.org/10.5565/rev/papers/v37n0.1595>
- Máttar, J. (2018). Desafíos de un buen gobierno: La profesionalización de la función pública. (Disponible en: http://www.foroconsultivo.org.mx/proyectos_estrategicos/img/8/34.pdf) y (Consultado: 05/11/2020).
- Mayorga, N. H. (2017). Monitoreo y evaluación ¿una práctica pendiente en las entidades en México? El caso del estado de Hidalgo. *Encrucijada, Revista Electrónica del Centro de Estudios en Administración Pública*, 27, 1-18. <https://doi.org/10.22201/fcpys.20071949e.2017.27.61231>
- Moreno Jaimes, C. (2007). Los límites políticos de la capacidad institucional: Un análisis de los gobiernos municipales en México. *Revista de ciencia política (Santiago)*, 27(2), 131- 153. <https://doi.org/10.4067/s0718-090x2007000300007>
- Nanjundan, S., Sankaran, S., Arjun, C. R., & Pavai, G. (2019). Identifying the number of clusters for KMeans: A hypersphere density based approach. *arXiv*. arXiv:1912.00643.
- Orozco Villafañe, A., Huerta Cuervo, R., & López Cruz, J. Y. (2018). Capacidades institucionales de los gobiernos municipales del Estado de Oaxaca. (Disponible en: <http://ru.iiec.unam.mx/4361/1/4-167-Orozco-Huerta-L%C3%B3pez.pdf>) y (Consultado: 05/08/2020).
- Otero, R. (2011). Política fiscal municipal con federalismo cooperativo hacendario: El sistema catastral como estrategia para incrementar la recaudación predial. (Disponible en: https://cefp.gob.mx/portal_archivos/convocatoria/pfp2011/pfp2011-2.pdf) y (Consultado: 16/08/2020).
- Polanco Martínez, J. M. (2016). El papel del análisis por componentes principales en la evaluación de redes de control de la calidad del aire. *Comunicaciones en Estadística*, 9(2), 271-294. <https://doi.org/10.15332/s2027-3355.2016.0002.06>
- Programa de las Naciones Unidas para el Desarrollo, PNDU (2019). Informe de Desarrollo Humano Municipal 2010–2015: Transformando México desde lo local. Mundiprensa. (Disponible en: <https://www.mx.undp.org/content/mexico/es/home/library/poverty/informe-de-desarrollohumano-municipal-2010-2015--transformando-.html>) y (Consultado: 10/09/2020):

- Romo de Vivar Mercadillo, M. R. & Gómez Monge (2016). Descentralización fiscal, capacidades administrativas y recaudación del impuesto predial en los municipios de México: Una aproximación teórica. *Economía y Sociedad*, 20(35), 155-170.
- Salinas, H., Albornoz, J., Reyes, A., Erazo, M., & Ide, R. (2006). Análisis de componentes principales aplicado a variables respecto a la mujer gestante en la Región de las Américas. *Revista Chilena de Obstetricia y Ginecología*, 71(1), 17-25. <https://doi.org/10.4067/s0717-75262006000100004>
- Sobarzo Fimbres, H. E. (2009). Relaciones fiscales intergubernamentales en México: Evolución reciente y perspectivas. *Problemas del Desarrollo*, 40(156), 11- 28. <https://doi.org/10.22201/iiec.20078951e.2009.156.7757>
- Sour Vargas, L. (2016). Una revisión del “efecto flypaper” mexicano (1990-2012). *Revista Mexicana de Análisis Político y Administración Pública*, 5(2), 9-28.
- Taguena, J., & León, M. (2011). La descentralización fiscal e independencia financiera local: Algunas dimensiones de desarrollo endógeno que influyen en el grado de independencia financiera para los municipios del estado de Hidalgo. Universidad Autónoma del Estado de Hidalgo. (Disponible en: https://www.uaeh.edu.mx/investigacion/productos/5077/la_descentralizacion_fiscal_e_independencia_financiera.pdf) y (Consultado: 12/08/2020),
- Tan, P. N., Steinbach, M., Karpatne, A., & Kumar, V. (2018). *Introduction to Data Mining* (2nd ed.). Pearson.
- Tepach Marcial, Reyes (2015). Recaudación de los ingresos públicos estatales y municipales del Estado de México, 2010-2013. Dirección General de Servicios de Documentación, información y análisis de la Cámara de Diputados. (Disponible en: <http://www.diputados.gob.mx/sedia/sia/se/SAE-ISS-17-15/Mexico.pdf>) y (consultado: 25/086/2020)
- Trujillo Salazar, L. P. (2008). Transferencias intergubernamentales y gasto local. Repensando la descentralización fiscal desde una revisión de la literatura. *Gestión y Política Pública*, 17(2), 451-486.
- Unda Gutiérrez, M., & Moreno Jaimes, C. (2015). La recaudación del impuesto predial en México: un análisis de sus determinantes económicos en el período 1969-2010. *Revista mexicana de ciencias políticas y sociales*, 60(225), 47-78. [https://doi.org/10.1016/s0185-1918\(15\)30019-2](https://doi.org/10.1016/s0185-1918(15)30019-2)
- Valenzuela Mendoza, R. E. (2013). El federalismo cooperativo como factor catalizador de un Gobierno Abierto. *Revista Mexicana de Ciencias Políticas y Sociales*, 58(219), 19-44. [https://doi.org/10.1016/s0185-1918\(13\)72302-x](https://doi.org/10.1016/s0185-1918(13)72302-x)
- Villanueva, L. F. A. (1996). El federalismo

mexicano: funcionamiento y tareas pendientes. *Revista Mexicana de Sociología*, 58(3), 3-37.
<https://doi.org/10.2307/3540873>

Villegas Corona V. A. (2017). Deuda pública de las entidades federativas y municipios en México: hacia un modelo de transparencia y vigilancia de los recursos. *Estudios en Derecho a la Información*, 3, 57-81. <https://doi.org/10.22201/ijj.25940082e.2017.3.10824>

Annex

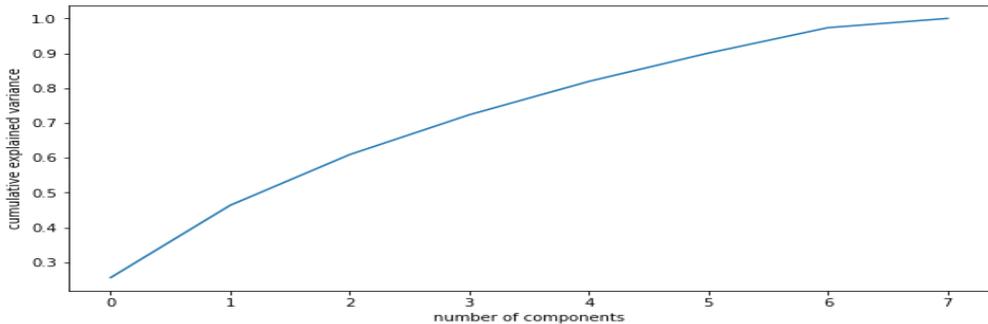


Figure A1. Accumulated Variance versus Number of Principal Components
 Note: "Number of components" in the x-axis, and "cumulative variance" in the y-axis
 Source: created by the authors using Python on Google's Colaboratory platform

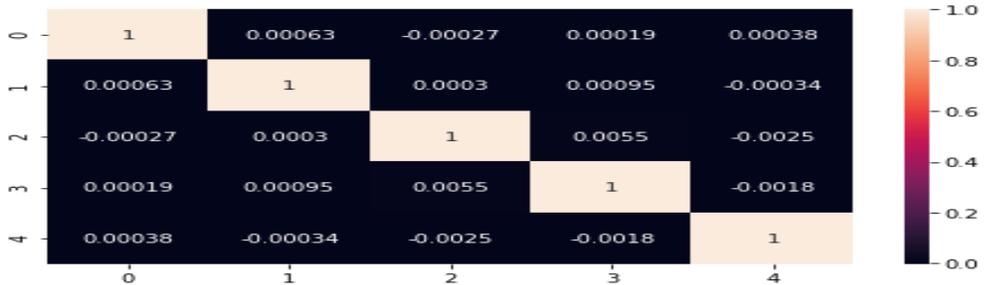


Figure A2. Covariance Matrix among Principal Components
 Note: If the value of the correlation between distinct principal components is closer to 0, the value is denoted in black. Number of principal components located on both axes (x-axis and y-axis).
 Source: created by the authors using Python on Google's Colaboratory platform

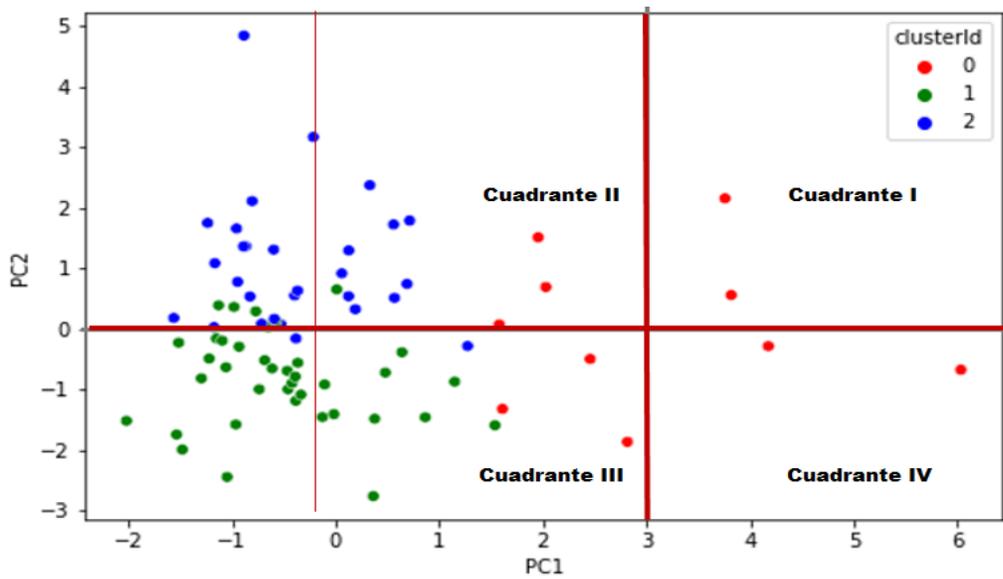


Figure A3. Formation of subgroups with respect to group 0 (red group) by quadrants.
Notes: Scatterplot of clusters for three groups or clusters ($k=3$), forming subgroups to cluster 0 (in red) and marked by quadrants. For the formation of these subgroups presented in Figure 2A, the authors superimposed the vertical and horizontal lines in red. Abbreviations: clusterid, cluster number; PC, principal component
Source: created by the authors using Python on Google's