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The Sustainability of Mexican Municipal Public Debt

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Abstract: This paper examines the sustainability of subnational governments in Mexico, focusing on its top 110 most indebted municipalities. We employ dynamic panel data techniques to assess whether municipal debt remained sustainable during 2007–2017. Our study finds that the subnational fiscal position of Mexican municipalities remains sustainable despite the rapid growth of public debt following the 2008 global financial crisis. However, using Monte Carlo simulations, we show that random disturbances can significantly impact municipal governments' debt, deteriorating governments' finances after the shocks materialize.

Keywords: public debt sustainability; panel data methods; Monte Carlo simulations

1. Introduction

The increasing relevance of subnational government finances has become a global trend. Canuto and Liu [1] observed that this growing importance has been driven by accelerated urbanization, increasing fiscal decentralization, and expansion of the debt market in developing countries. Mexico has been experiencing these phenomena for the last two decades. Regarding urbanization, Kim and Zangerling [2] highlight the rapid growth of Mexican cities outside the capital. The authors indicate that large Mexican cities have experienced an average annual population growth of 4.9 percent between 1990 and 2010, whereas the national average was 1.6 percent. Urban expansion outside the country's capital has increased the political pressure to decentralize federal government finances.

Recurring financial crises have been another factor driving Mexico toward decentralization. After the mid-1990s financial crisis in Mexico, the federal government began to decentralize subnational finances. One of the most significant decentralization policies granted local governments increased capacity to participate in the emergent short and long-term debt markets. This increasing financial decentralization developed the subnational debt market. However, the policy resulted in a widespread increase in subnational indebtedness at present. The municipalities' total debt has increased by 77 percent in real terms since 2003, whereas the debt of the states has increased by 119 percent. However, the growth of the subnational debt in Mexico has been characterized by its heterogeneity. Certain entities maintained a healthy debt level, whereas others have raised their indebtedness to alarming levels.

Debt level increases do not necessarily represent a threat to public finances, unless it becomes unsustainable, i.e., when the costs of debt represent an excessive burden on public finances [3]. A sustainable indebtedness path must be differentiated from a non-sustainable one to identify the risks of high debt levels. Accordingly, economists have focused their studies on the sustainability of public debt since the 19th century. The subject has been intensely debated and analyzed through multiple methods [4]. This methodological debate continues because no consensus has been reached on the definition of sustainability [5] and the conditions for its definition [6].

The existing literature presents two main methods for assessing public debt sustainability: the traditional method for unit root testing [7–9] and Bohn's budget constraint

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model [10]. Bohn's model has gained popularity due to its flexibility and statistical properties. However, Cabral, del Castillo, and Hernández-Trillo [11] have recently derived a sustainability indicator based on a balanced budget constraint that provides an intuitive interpretation of sustainability. In this paper, we will use this indicator to assess debt sustainability.

Public debt sustainability conditions regained relevance in the academic literature after the 2008 financial crisis. Subsequently, several studies have focused on the sustainability of debt at the national level [12–15]. However, Canuto and Liu [1] noted the growing importance of subnational debt and the need to assess its sustainability. Accordingly, many studies began to investigate subnational debt sustainability at the state level [16–18] and municipal level [19,20].

In Mexico's case, we found public debt sustainability studies only at the national [21] and state levels [11]. Multiple works analyze public debt determinants at the municipal level [22]. However, to our knowledge, no studies have previously evaluated the sustainability of Mexico's debt at the municipal level. Hence, this paper is the first to present a formal assessment of municipal debt sustainability using econometric methods. We use dynamic data panel techniques (System Generalized Method of Moments [SGMM]) to evaluate the sustainability of the 110 most indebted Mexican municipalities. Then, we explore the impact of financial shocks on debt sustainability. These financial shocks hit Mexico and other emerging market economies' subnational governments, following the recent COVID-19 pandemic.

Local (municipal) governments' fiscal sustainability is an important topic that has not been adequately studied. This topic requires considerable attention as economies, particularly emerging markets, become increasingly exposed to foreign shock influence. Our assessment results indicate that the municipalities' debt has remained sustainable despite the recent global financial crisis's adverse effects. However, we notice that the sustainability indicator has been deteriorating over time. Multiple robustness tests through regional, temporal, and measurement differences confirm that our results remain reliable across several specifications. Furthermore, our Monte Carlo simulation results suggest that extreme financial shocks, such as those caused by the COVID-19 pandemic, reduce long-term sustainability.

The rest of the article is organized as follows. Section 2 summarizes the Mexican subnational debt and reviews the sustainability literature. Section 3 describes the data and methods used. Section 4 analyzes the estimation results. Lastly, Section 5 discusses the results and presents the conclusions.

2. Literature Review

2.1. Institutional Background

Mexico is a federation comprising thirty-two sovereign states, each of which constitutes municipalities as the most fundamental political and administrative units. The country has 2477 municipalities with limited fiscal sovereignty. Historically, Mexico has maintained a highly centralized tax collection system in which the central government used to collect nearly 95 percent of the country's total taxes [23].

Fiscal centralization has led subnational governments to highly depend on federal transfers. This dependency has reduced local governments' efforts to collect their tax revenue and has increased the moral hazards of bailouts due to bankruptcy [24]. These circumstances have exposed subnational governments to financial shocks, as the 1995 domestic crisis demonstrated. Several subnational governments were financially exposed and suffered bankruptcy during this crisis. As a result, the federal government bailed out several states through extraordinary transfers and debt restructuring support [25].

The 1995 Mexican financial crisis was caused by the central government's macroeconomic mismanagement, including its public debt balance. Nevertheless, the central government learned to improve its fiscal position and debt management. Since 1998, the central government's primary deficit has been close to being balanced, and its public

debt-to-GDP ratio has remained low. Moreover, the federal government promoted new legislation in subnational entities to decentralize the tax revenue and prevent future bailouts.

In 1997, a new subnational fiscal regulatory framework was introduced to reduce federal transfers' discretion in differentiating conditional (aportaciones) from the non-conditional (participaciones) resources. The new regulation allowed subnational governments to collateralize non-conditional transfers to obtain financing. The reform also aimed to increase debt market transparency by requiring at least one of the federal government-approved rating agencies (i.e., HR Ratings, Fitch Ratings, Moody's, and Standard and Poor's) to have evaluated the local government's debt issuance. However, these efforts have not reduced tax revenue centralization. On average, approximately 85 percent of state and municipality revenues still depend on federal transfers, whereas nearly 8.4 percent are local government revenues [26]. Furthermore, the reform allowed the subnational governments to borrow from development and commercial banks under market conditions [25]. Consequently, subnational debt increased rapidly since 2003, by 119 and 77 percent for states' and municipalities' total debt, respectively.

Existing literature has identified two causes of the increase in subnational debt, which are related to the 1997 fiscal reform deficiencies [23,27]. First, the reform lacked normative mechanisms that granted discretionary powers to entities to define and delimit debt levels. Furthermore, the legislation lacked standardized accounting criteria for entities. As a result, each government exercised accounting discretion, resulting in difficulty determining the real indebtedness level. The reform also delegated power to local legislation to establish explicit limits to debt levels. Astudillo et al.'s analysis of the legislation reveals that less than half of the local legislatures established explicit limits for state and municipal indebtedness in two decades [27]. Second, the reform lacked monitoring mechanisms. The new legislation required entities to register loans to the central fiscal authority and periodically publish the debit balances. However, no mechanisms were developed to track loan balance across time. In addition, penalties for non-compliance with regulations were not established. The responsibility for monitoring and evaluating subnational debt was indirectly delegated to the rating agencies. However, the rating agencies had difficulty determining the real indebtedness level and subnational governments' borrowing capacity, probably due to regulatory deficiencies. Evidence also suggests that the rating agencies in Mexico were influenced not only by financial factors but also by political considerations [28].

The 2008–2009 global financial crisis was another factor that contributed to the increase in subnational public debt. The crisis was characterized by decreased oil prices, a restrictive credit market, low investment levels, and low-to-negative economic growth. These circumstances impacted subnational government tax revenues and, therefore, the capacity to pay debt service. This condition resulted in an increase in debt balances. However, the impact of the global crisis was much lower than that of the 1995 domestic crisis. Revilla attributed the lessened impact of the crisis on the Mexican subnational government finances to three factors [29]. First, a decade of fiscal and monetary discipline allowed the federal government to maneuver during the crisis. Second, the central fiscal authority's prevision through rainy day funds and oil hedges during the years of oil revenue bonanza flattened the decline in federal transfers during the crisis. Third, by law, the subnational debt is denominated in the local currency, thus avoiding currency depreciation impacts. Subnational government finances may have collapsed without these three factors.

The central government's timely intervention prevented the collapse of subnational government finances but not the increase in debt balances. Figure 1 reveals that total state and municipal subnational public debt increased sharply after the 2008–2009 financial crisis. We measure total municipal public debt as a proportion of total subnational debt and find that the proportion has remained relatively low but in an increasing trend, from 12 percent in 2013 to approximately 16 percent in 2016 [23].

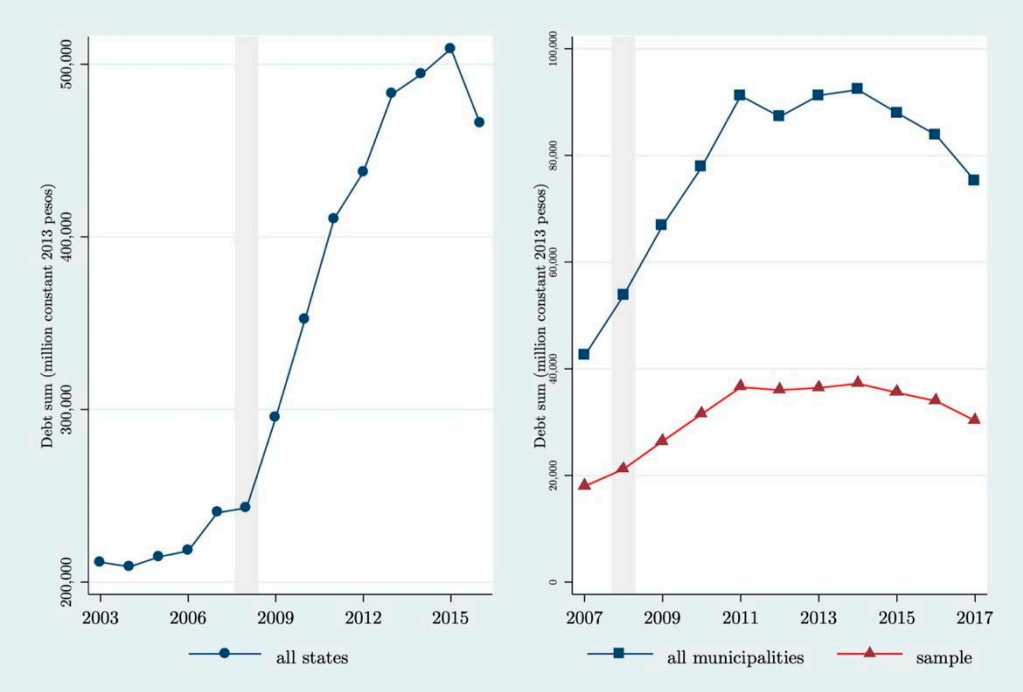

Figure 1. Evolution of Total Subnational Debt. Note: Shaded areas indicate the beginning of the 2008 global financial crisis.

Motivated by the growth of subnational debt, the federal government enacted a series of reforms to improve subnational debt regulations due to its excessive growth. In 2013, a new robust regulatory framework, namely, the Ley General de Contabilidad Gubernamental (LGCG), was commenced to end the accounting discretion. The LGCG establishes standardized accounting criteria and regulates financial reporting of all government authorities. It establishes subnational governments' periodic obligation to publish harmonized financial statements, including their net indebtedness levels.

The Ley de Disciplina Financiera de las Entidades Federativas y los Municipios (LDFEFM) was approved in 2016 to complement the LGCG. Then, other complementary laws were reformed to promote the subnational governments' financial discipline. Accordingly, the legislation establishes five mechanisms to improve transparency and accountability. Three of these mechanisms stand out: a unique public record of financial obligations for all subnational governments; a quarterly system of alerts for subnational government credit risk to monitor and evaluate subnational indebtedness levels, debt service payment, and all subnational entities' liquidity conditions; and a secured debt mechanism to encourage the best financial practices. The central government grants credit guarantees to subnational governments' debt issuance that subscribe to a financial discipline agreement through the secured debt mechanism. The credit guarantee intends to reduce the financing costs of those who subscribe to the agreement.

Although it is premature to judge the most recent reform, the literature indicates that increasing transparency and accountability controls reduce Mexican subnational governments' indebtedness [27]. However, Villegas warns that the latest regulatory framework has legal voids that impede the real transparency and accessibility of the disposition of resources obtained through public debt [30].

2.2. Debt Sustainability Review

Public debt sustainability has been part of a broad debate in theoretical and empirical economic literature. Neck and Sturm emphasize that the debate began in the 19th century with the Ricardian hypothesis of government debt neutrality [5]. Ricardo also contributed to the debate by arguing about the intergenerational distribution of debt burden. A century

later, the Keynesian school of thought revisited Ricardo's intergenerational argument by proposing that deficits are desirable to distribute long-term investment costs in public projects between generations and stimulate aggregate demand in the short term.

Subsequently, Domar built on intertemporal budget restriction and defined the first mathematical condition to guarantee public debt sustainability (i.e., the deficit-to-GDP constant ratio) [31]. Moreover, Barro proposed the theory of tax smoothing under the hypothesis that the present net value of expenditure is equivalent to that of future taxes [32]. Then, Bohn incorporated into his model the elements of Barro's fiscal model [32] to derive a fiscal reaction function as a mechanism for assessing debt sustainability [10].

Although sustainability has been debated extensively, a consensus about its definition [5] and the conditions to guarantee its definition [6] has not been reached. Balassone and Franco held that the problem is that sustainability assessments are based on partial equilibrium models that do not completely consider the interactions between the public budget and macroeconomic variables [3]. However, the literature highlights two econometric methods for evaluating the sustainability of public debt policy: the unit root test [7–9] and Bohn's fiscal reaction empirical test [10].

The traditional unit root method examines whether the debt-to-GDP ratio time series is non-stationary, that is, whether the debt-to-GDP ratio increases in real terms above the future value of the discounted fiscal surpluses [5]. If public debt is non-stationary, then the debt is unsustainable. However, this method has been criticized because of the difficulty of rejecting a unit root in a series of debt as a proportion of the GDP [18] and its high sensitivity to structural changes in the time series [33].

Bohn addressed the deficiencies of the unit root approach by proposing a model that examines fiscal reaction to changes in the debt-to-GDP ratio [10]. Bohn's fiscal reaction function implies that if governments aim to increase their debt in the present, they will have to increase their fiscal surplus in the future as a corrective measure. This condition implies that the proportion of debt to GDP would tend to revert to the mean, therefore reaching a sustainable debt level. Bohn's model also shows that the fiscal reaction is independent of interest rate and thus has no assumptions about its future values.

Given its properties, Bohn's model [10] has been widely used for assessing debt sustainability at the national [12,13,34] and subnational levels [16,18,35]. In this article, we assessed municipal debt sustainability using two methods. First, we performed the unit root test. Second, we departed from Bohn's model and followed Cabral et al.'s [11] econometric approach based on Wickens's work [36]. Section 3 discusses this model further.

3. The Model

This paper's empirical model is derived from Wickens's present value constraint framework [36]. The starting point of the model is the government budget constraint (GBC) as follows:

$$P_t g_t + (1 + R_t) B_{t-1} = B_t + P_t \tau_t \quad (1)$$

where the subscript t indicates the time period, P_t is the price level, g_t is the real government expenditure, τ_t is the real tax revenue, B_t is the government nominal bonds value at the end of period t, R_t is the bonds' interest rate issued in period t, and, $R_t B_{t-1}$ is the total interest paid during period t on bonds issued during $t-1$.

Then, we obtain the GBC in terms of the GDP by dividing Equation (1) by the nominal GDP ($P_t y_t$) as follows:

$$\frac{g_t}{y_t} + (1 + R_t) \cdot \frac{B_{t-1}}{P_{t-1} y_{t-1}} \cdot \frac{P_{t-1}}{P_t} \cdot \frac{y_{t-1}}{y_t} = \frac{b_t}{y_t} + \frac{\tau_t}{y_t} \quad (2)$$

Next, Equation (2) is re-expressed as follows:

$$\frac{g_t}{y_t} + \frac{(1 + R_t)}{(1 + \pi_t)(1 + \gamma_t)} \cdot \frac{b_{t-1}}{y_{t-1}} = \frac{b_t}{y_t} + \frac{\tau_t}{y_t}$$

The public deficit is defined as follows: $P_t D_t = B_t - B_{t-1}$. Re-expressing this formula in terms of Equation (1), we obtain $P_t D_t = P_t g_t - P_t \tau_t + R_t B_{t-1}$. Subsequently, we can define the government's real deficit in terms of GDP as follows:

$$\frac{D_t}{y_t} = \frac{g_t}{y_t} - \frac{\tau_t}{y_t} + \frac{R_t}{(1+\pi_t)(1+\gamma_t)} \cdot \frac{b_{t-1}}{y_{t-1}} \tag{3}$$

or re-expressing Equation (3) as:

$$\frac{D_t}{y_t} = \frac{b_t}{y_t} - \frac{1}{(1+\pi_t)(1+\gamma_t)} \cdot \frac{b_{t-1}}{y_{t-1}}$$

Then, defining the nominal primary deficit as $P_t d_t = P_t D_t - R_t B_{t-1}$ and using Equation (3), we define the primary deficit-to-GDP ratio as follows:

$$\frac{d_t}{y_t} = \frac{g_t}{y_t} - \frac{\tau_t}{y_t} \tag{4}$$

Defining π_t as the inflation rate, and γ_t as the real GDP growth, we can re-express Equation (4) as follows:

$$\frac{d_t}{y_t} = \frac{b_t}{y_t} - \frac{(1+R_t)}{(1+\pi_t)(1+\gamma_t)} \cdot \frac{b_{t-1}}{y_{t-1}}$$

where

$$1 + \rho_t = \frac{(1+R_t)}{(1+\pi_t)(1+\gamma_t)} \cdot \frac{b_{t-1}}{y_{t-1}}$$

Thus, $\rho_t = R_t - \pi_t - \gamma_t$ is the real interest rate adjusted by the real GDP growth. Then, solving for the current debt-to-GDP ratio, we can re-express Equation (4) as follows:

$$\frac{b_t}{y_t} = (1+\rho_t) \cdot \frac{b_{t-1}}{y_{t-1}} + \frac{d_t}{y_t} \tag{5}$$

Therefore, Equation (5) proposed by Wickens shows that the current debt-to-GDP ratio depends on the same ratio of the previous period, current primary deficit-to-GDP ratio, and long-term stability parameter ρ_t [36]. Assuming a constant nominal interest rate, inflation, and real GDP growth and using a backward solution, the debt-to-GDP ratio converges to a finite level in the long term and is sustainable when $\rho_t < 0$. Otherwise, the debt-to-GDP ratio goes to infinity, and the government fiscal position becomes unsustainable in the long term.

We extend Equation (5) to accommodate an estimable panel data specification as follows:

$$\frac{b_{it}}{y_{it}} = \alpha_i + \lambda_t + \beta \frac{b_{it-1}}{y_{it-1}} + \delta \frac{d_{it}}{y_{it}} + X\Gamma + \epsilon_{it} \tag{6}$$

where λ_t and α_i are time and fixed effects, respectively.

We must consider the nominal municipal GDP to estimate Equation (6). However, this measurement is unavailable in Mexico at the municipal level. Therefore, we propose to approximate it using an alternative measure. Following Cabral et al., we estimate Equation (6) by employing guaranteed resources (income plus non-conditional transferences) as GDP alternative [11]. In contrast with central fiscal authorities, municipalities have limited availability to collect taxes; thus, the use of guaranteed resources is reasonable.

In Equation (6), X is a vector of control variables that impact public debt growth. Several control variables have been explored in the literature as relevant determinants of long-term debt accumulation. For example, the output gap and government expenditure gap had been employed by national-level debt sustainability assessments [34,37]. For subnational evaluations, local population [17,24] and political factors [38] were relevant

control variables. We also hypothesized that the 2008–2009 global financial crisis may have indirectly affected subnational debt growth, as the literature suggests [1,39]. Thus, we consider a control variable for its effects. Finally, we also incorporated a measure for credit risk ratings as a control variable that the literature views as a relevant factor [40]. Section 4 below discusses the details of our methods.

4. Empirical Methods

4.1. Data

We constructed a slightly unbalanced annual panel dataset for the period 2007–2017. We used two sampling criteria considering the data availability and heterogeneity of the 2477 municipalities. First, we discard municipalities without consistent financial data throughout the study period. Second, the municipalities are required by law to have at least one credit rating to be eligible for an increase in indebtedness. Thus, we included only those rated over six years during the analysis period. As a result, our final sample comprises 110 municipalities.

Although the sample represents only 4.4 percent of all municipalities in 2017, they constitute 42 percent of the national population and 43 percent of the total municipal debt.

The data are collected from different Mexican and international sources. The financial variables of municipalities, the population statistics, and the political variables are obtained from the National Institute of Statistics and Geography, National Population Council, and state and federal electoral organizations, respectively. We also obtained the national scale ratings of each municipality from four major agencies: Fitch Ratings, Moody's, Standard and Poor's, and HR Ratings. We obtained these ratings through Thomson Reuters Eikon.

We use the proportion of debt to guaranteed revenue for our dependent variable. As discussed above, we estimate Equation (6) using the guaranteed revenue. This revenue is widely used by rating agencies to assess subnational governments' borrowing capacity. Moreover, the original qualitative rating values were transformed to ordinal values, following a previous transformation [28]. In contrast, our scale, ranging from 1 to 9, was coded using data from the four largest rating agencies operating in Mexico. Our transformation also ranks risk ratings from low to high on a scale, where values closer to one indicate lower risk.

Subnational governments can hire any rating agencies' services. Sometimes, they stopped using one agency's service to hire a competitor. Consequently, not all municipalities across all agencies have available data. We used standardized coding to estimate a global risk rating for each municipality based on available ratings to avoid information loss. We calculated global indicators based on three metrics: minimum, median, and maximum rating. We considered the maximum rating as the most appropriate measure, as we hypothesize that credit markets may consider the riskier indicator to assess their business risk. We will employ the maximum rating in our main analysis, and the other measures will be used for robustness check purposes.

As discussed earlier, political factors are relevant, considering that municipalities require local congressional approval to issue additional public debt. Moreover, the local congress examines and approves the yearly municipal finance audits. Therefore, having political allies in the governor's office and a majority in the local congress may facilitate the municipal public debt's approval. We control for this effect including a dummy variable that equals one if the same political party simultaneously holds the governor's office, municipal office, and a majority (50 percent + 1) in the local congress, and zero otherwise. Lastly, we capture the negative impact of the global crisis on GDP growth (−6.1 percent in 2009) by including a crisis dummy variable that equals one for 2009 and zero for other years. We hypothesize that all three factors—namely, government debt ratings, financial crisis, and political affinity—significantly impact the municipal public debt accumulation in the long run.

Table 1 shows the descriptive statistics of the variables included in the model. The panel is slightly unbalanced due to 108 missing values of the credit rating variable.

Table 1. Panel Descriptive Statistics (2007–2017).

Variable	N	Min	Mean	Max	sd
Debt (in million pesos)	1210	0	276.83	2711.92	413.04
Primary balance (in million pesos)	1210	0	98.35	2567.46	193.98
Primary balance to guaranteed revenue ratio	1210	0	0.14	2.31	0.20
Debt to guaranteed income ratio	1210	0	0.29	2.58	0.28
Debt per capita (pesos)	1210	0	643.61	4271.03	688.83
Political affinity	1210	0	0.19	1	0.39
Credit Rating	1102	1	2.70	9	1.29
2009 crisis dummy	1210	0	0.09	1	0.29

Note: Monetary amounts expressed in inflation- adjusted pesos. The base year is 2013 (INPC = 100).

4.2. Estimation Methods

First, we performed a correlation analysis on the variables and discarded multicollinearity issues. Then, we performed a unit root analysis for the variables of interest: the debt-to-guaranteed revenue ratio and primary balance-to-guaranteed revenue ratio. If the series contains a unit root, then it would imply an unsustainable fiscal stance, because they would tend to diverge from equilibria over time. Following Baltagi and Kao [41], we employed the Levin–Lin–Chu (LLC) panel test under the null hypothesis of non-stationarity. We also performed the test under two specifications, namely, with and without time trend. Table 2 presents the test results, rejecting the null hypothesis for all cases. Thus, the series are stationary, suggesting that the Mexican municipal debt is sustainable.

Table 2. Panel Unit Root Tests.

Test Type	Variable	LLC Panel Unit Root Tests			
		N × T	Statistic	*p*-Value	Lags
Intercept only	Debt to guaranteed resources ratio	1210	−13.167 ***	[0.000]	0.1909
Intercept and trend	Debt to guaranteed resources ratio	1210	−22.235 ***	[0.000]	0.3091
Intercept only	Primary deficit to guaranteed resources	1210	−25.59 ***	[0.000]	0.2273
Intercept and trend	Primary deficit to guaranteed resources	1210	−28.282 ***	[0.000]	0.3636

Note: The reported statistics are for the series in levels. The number of cross-section units is always 110. For panel unit roots LLC under the unit root null, the p-values are given in brackets. The number of lags was chosen using the Schwarz criteria. *** denotes a level significance of 1 percent.

Although the test results show stationarity, Bohn warned about the difficulty of rejecting a unit root in a time series of debt as a proportion of GDP [10]. Moreover, Uctum and Thurston reported evidence suggesting a high sensitivity of unit root test to structural changes in a time series, such as that generated by the global financial crisis [33]. Hence, we employ the model specification discussed above to obtain a robust and intuitive debt sustainability evaluation.

Using OLS on Equation (6) is known to produce inconsistent estimations. The original Bohn model uses OLS and employs contemporary regressors (GDP growth and public spending) on the right-hand side [10]. This, of course, causes potential endogeneity problems that might not be prevented using OLS. The model employed in this paper, originally by Cabral et al. [11], employs the SGMM econometric techniques proposed by Blundell and Bond and prevents potential endogeneity problems associated with the presence of the lagged dependent variable as a regressor [42]. Thus, we must employ a different approach to deal with the correlation between the lagged dependent variable and fixed effects in the error term. Two plausible estimators can purge the fixed effects: the Difference Generalized Method of Moments (DGMM) and SGMM. DGMM solves the OLS consistency problem by taking first-differences, removing the municipal effects, and producing an equation estimated by employing instrumental variables. However, Roodman warned that DGMM magnifies gaps in unbalanced panels [43]. Under SGMM, endogenous explanatory variables are controlled using their lagged values, exploiting all the moments'

conditions through a system of first differences and levels equations to generate robust estimations [42]. We estimated Equation (6) using SGMM, considering its robustness and the vulnerability of DGMM to unbalanced panels. Nevertheless, according to Blundell, Bond, and Windmeijer, SGMM estimators are consistent only if the residuals do not exhibit second-order autocorrelation and if Hansen's J-test does not reject the null hypothesis (i.e., the instrumental variables are valid) [44]. Therefore, we perform both tests in the following section.

Regarding the instrumental variables' validity, Roodman noted that excessive instrumental variables overfit endogenous variables and weaken their Hansen's J-test on their joint validity [45]. We report the number of instrumental variables and observations to ensure the robustness of our results. In general, the number of instrumental variables in the sample must not exceed that of the municipalities to avoid over-identification issues.

5. Empirical Results

5.1. Main Results

Table 3 presents the main estimation results of Equation (6) using SGMM under its two-step procedure. In addition to presenting the entire sample estimates (column (1)), Table 3 also presents the results obtained from the four regional partitions (columns (2)–(5)) to consider Mexico's prevailing regional heterogeneity.

Table 3. SGMM Estimations.

Dependent Variable *Debt to Guaranteed Revenue*	**Main and Regional Partition Results**				
	Main	**North Border**	**North Central**	**Central**	**South**
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Lagged debt	0.642 ***	0.468 ***	0.810 ***	0.754 ***	0.558 ***
	(0.067)	(0.134)	(0.237)	(0.099)	(0.151)
Primary balance	0.310 ***	0.302 **	0.289 ***	0.277 ***	0.418 ***
	(0.041)	(0.131)	(0.097)	(0.076)	(0.085)
Credit Rating	0.014 **	0.021	0.020 ***	0.019	0.014
	(0.007)	(0.015)	(0.006)	(0.027)	(0.018)
Political affinity dummy	−0.027	−0.072 *	0.045	−0.009	−0.04
	(0.019)	(0.043)	(0.041)	(0.024)	(0.062)
2009 crisis dummy	−0.004	−0.009	0.079	−0.011	−0.075 *
	(0.017)	(0.05)	(0.05)	(0.032)	(0.042)
Constant	0.026	0.111 *	-0.052	−0.024	0.045
	(0.025)	(0.057)	(0.073)	(0.069)	(0.069)
Implicit ρ	**−0.358**	**−0.532**	**−0.190**	**−0.246**	**−0.442**
Number of observations	1019	287	289	316	127
Number of instruments	31	8	8	8	8
Number of municipalities	110	30	31	35	14
AB (1)	−1.719	−1.332	−2.246	−3.15	−2.128
AB (1) *p*-value	[0.086]	[0.183]	[0.025]	[0.002]	[0.033]
AB (2)	1.105	1.034	0.882	0.263	1.334
AB (2) *p*-value	[0.269]	[0.301]	[0.378]	[0.792]	[0.182]
Hansen test	24.351	2.478	3.772	4.192	3.15
Hansen test *p*-value	[0.499]	[0.290]	[0.152]	[0.123]	[0.207]

Note: Heteroscedasticity robust standard errors are shown in parentheses. Hansen's J-test reports that under the null hypothesis, the overidentified restrictions are valid. *p*-values shown in brackets. AB (1) and AB (2) correspond to the Arellano–Bond test for serial correlation, under the null hypothesis of no autocorrelation. *p*-values shown in brackets. *, **, and *** refer to levels of significance of 10, 5, and 1 percent, respectively.

In Table 3, the entire sample estimates (column (1)) show that our main variables of interest (lagged debt and primary balance) exhibit the expected sign (positive) and are highly significant. Both coefficients also display the largest magnitudes in the regression. The credit rating ratio has the expected sign (positive) and is significant. We observe a negative and nonsignificant coefficient for the political affinity variable. Regarding the crisis variable, we do not observe the expected sign, although it is not significant. All control variables show moderate coefficients. The negative sign of the interest parameter (implicit $\rho = -0.358$) confirms that the debt remained sustainable for the entire sample.

The regression analysis discards second-order autocorrelation. Following Roodman's advice [45], the number of instrumental variables does not exceed that of the municipalities. Hansen's J-test results also support the null hypothesis (i.e., the instrumental variables are valid). Overall, our main results are robust, though we do not observe the expected signs for the political affinity and crisis dummy variable.

5.2. Robustness Analysis

Regional robustness. Table 3 presents the estimates of the four regional partitions (columns (2)–(5)) to consider Mexico's regional heterogeneity. These regional partition results can be interpreted as evidence of robustness.

We observe positive coefficients of the lagged dependent variable, which are less than the unit and highly significant. However, the Central North (column (3)) and Central (column (4)) regions show significantly higher coefficients, indicating lower coefficients of their ρ. Thus, these regions are less sustainable than the North and South regions. We also observed positive and highly significant values for primary balance in all regions, which are nearly 0.3. However, the South region's primary balance is higher than 0.4, suggesting that the municipalities in the south are more sensitive or inclined to acquiring debt, following the changes in this variable, ceteris paribus. Furthermore, we found that the variable credit rating shows the expected (positive) sign in all regions, though significant only for the Central North region. The result suggests that the municipalities in this region are the most sensitive to credit rating changes, ceteris paribus.

We found negative coefficients for political affinity variable in all regions, except in the Central North. However, the coefficients are not significant, except for the North border region, which is only significant at 10 percent. Although the variable's negative coefficient is counterintuitive, Carpizo's work in Mexican states could explain this condition [46]. Carpizo shows that highly competitive electoral environments tend to maintain high debt levels. In these environments, an absolute majority in the local congress does not support the governor. Carpizo argued that electoral competition motivates incumbent governments to raise public spending and borrowing to gain an electoral edge for their party during an election. Although Carpizo's argument could explain the variable's negative coefficient, testing its veracity is beyond this article's scope. However, future research could explore this hypothesis.

We notice a similar pattern of the variable crisis to that of the political affinity variable, indicating negative coefficients for all regions, except in the Central North. However, the coefficients are not significant, except for the South region, where it is significant at 10 percent.

All regions remained sustainable ($\rho < 0$). However, we observe that the Central ($\rho = -0.246$) and North Central regions ($\rho = -0.190$) present the less sustainable fiscal stances, whereas the North Border region is the most sustainable ($\rho = -0.532$). The estimation result of all the partitions rejected the second-order autocorrelation, whereas it supported the validity of the instrumental variables. In sum, we observe consistency in the results across all partitions, indicating that the model is robust to regional differences.

Alternative models. We performed several estimations to corroborate our model robustness. First, we used two alternative measures (mean and mode) for the variable credit rating. The coefficients preserve their sign, magnitude, and significance level; therefore, the results remain consistent across measurements. Second, we tested the temporal consistency of the coefficients by partitioning the sample using a pivot technique. The results show that the main variables' sign, magnitude, and significance remain consistent over time. However, we noticed that the sustainability indicator shows a growing trend over time, indicating declining sustainability, especially after the 2008 crisis.

5.3. Monte Carlo Simulations

We evaluate the robustness of the sustainability indicator (ρ) using Monte Carlo simulations to test the stability of ρ under thousands of simulated scenarios, with varying uncertainty levels, including random financial shocks.

We performed the Monte Carlo simulations in three steps. First, we simulated a dynamic panel dataset of 120 municipalities (i), observed over 15 years (t) using Stata, following Moffatt's guidelines [47]. In this step, the data generation process of the simulated panels is based on a previous regression using the Arellano and Bond estimator [48]. We use this estimator to obtain the lagged variables of interest coefficients in Equation (6). Thus, each simulated variable (v_{it}) is a function of its first lag (v_{it-1}), a constant term (α_i), a positive trend (γ_t), and a normally distributed random error (ε_{it}).

In the second step, we specified the SGMM regression model to be estimated iteratively using Stata. The model is essentially the same as Equation (5). We ran two thousand simulations, each representing two thousand simulated panels with their corresponding regressions. In total, we simulate 3.6 million data points (120 municipalities × 15 years × 2000 simulations). From each simulation, we calculated a distinct estimation of ρ_t, from which we can construct its distribution. Then, we contrasted the actual estimation ($\hat{\rho}_t = -0.358$ from Table 3) against the simulated distributional mean ($\rho_t = -0.382$). Panel A in Figure 2 shows the distribution of the simulated parameter contrasted against the observed parameter. The ρ_t mean from the simulated data falls within the 95 percent confidence interval of the real estimation ($\hat{\rho_t}$), indicating a relatively stable parameter.

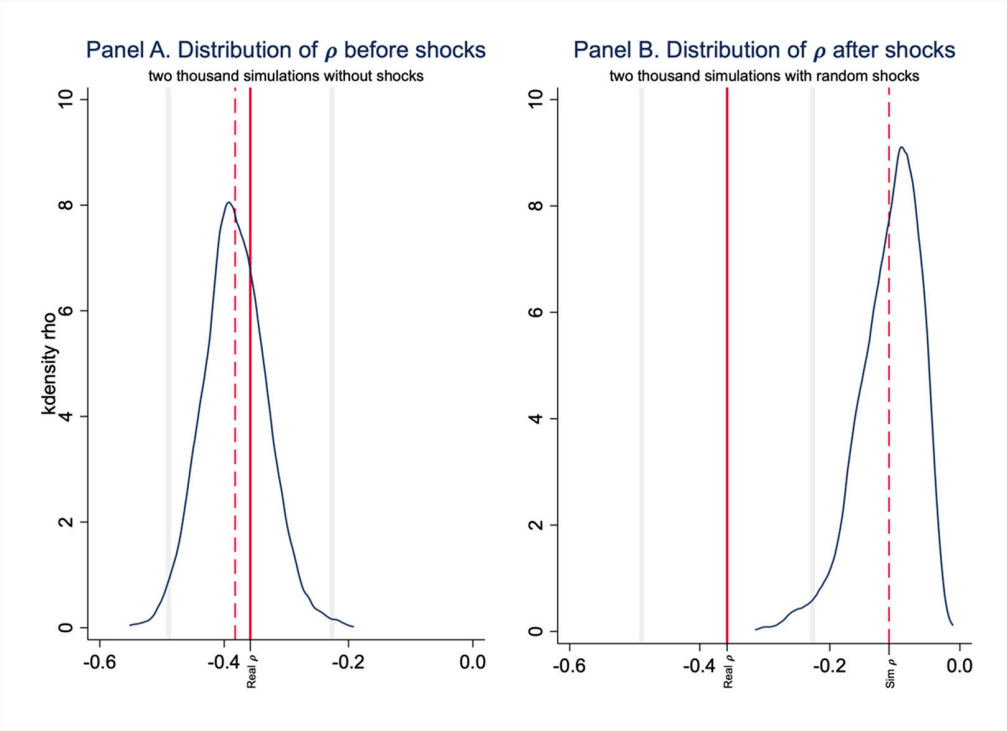

Figure 2. Simulated ρ_t distribution before and after shocks. Note: Real ρ 95% confidence interval denoted by grey lines. Simulated ρ mean represented by dashed lines.

As a third step, we extended the model to incorporate random shocks that simulate periods of financial distress to test the limits of ρ_t under severe variability. In this scenario, ρ_t is expected to move closer to zero (or become positive) with increasing levels of financial shocks. Here, the strategy consists in simulating random shocks that simultaneously affected all municipalities at a given time. The shocks were modeled by approximating the Poisson distribution using a sequence of discrete Bernoulli events with probability p of occurrence. We tested several values of p and found that when $p = 0.12$, three to four

random shocks are expected to occur during the 15 years of the simulated panel. Therefore, a random shock is expected to occur approximately every 5 years based on the simulations. The magnitude of the shock was simulated using a normal distribution with a positive mean and finite variance ($\mu = 0.08$, $\sigma = 0.03$). The shocks were also modeled to have repercussions (80 percent of its initial magnitude) in the year after it occurred. Panel B in Figure 2 shows the distribution of the simulated ρ incorporating random shocks, where the distribution (and ρ_t) shifted closer to zero, signaling a less sustainable position, as predicted by the model.

In summary, the simulations present evidence of the robustness and stability of ρ, the indicator of interest. They also suggest that the financial stances of municipal governments can significantly deteriorate when extreme random financial shocks occur, such as those caused by the 2008 global financial crisis and COVID-19. This finding is relevant, considering that the Mexican subnational governments experienced their last bailout in 1995 after the country experienced a significant financial shock following a crisis of local origin. This event occurred when the Mexican economy was not as exposed to shocks of foreign origin, unlike today. In the absence of complete data to assess the full impact of the global pandemic, this simulation exercise allows us to foresee the impact of COVID-19 on municipal debt sustainability.

6. Conclusions

The Mexican federal government implemented reforms after the 1995 local crisis to prevent further financial bailouts for subnational entities. However, the subnational governments have increased their level of public debt. The objective of this study was to evaluate the sustainability of the 110 most indebted Mexican municipalities. This article contributes to the literature by performing the first public debt sustainability assessment at the municipal level using dynamic panel techniques (SGMM) following the approach suggested by Wickens [36]. In addition to traditional unit root tests for assessing debt sustainability, we performed two thousand Monte Carlo simulations to test the stability of the proposed indicator. The results confirm its reliability under varying levels of financial stress. Our results also indicate that the assessed municipal debt has remained sustainable despite the adverse effects of the 2008–2009 global financial crisis. However, the sustainability indicator (ρ) has deteriorated over time.

We urge constant public monitoring of debt sustainability as a policy implication, especially after the COVID-19 economic crisis. Our evaluation included three control variables. First, the credit rating variable was consistently significant when using the highest risk rating available. Second, the political affinity variable, which sought to capture the effects of partisan coincidence between municipal authorities, state governments, and a majority in the local Congress, showed regional statistical significance. However, there is not enough evidence to conclude that there is a partisan effect on municipal debt accumulation. However, it is left for future investigations to explore Carpizo's hypothesis that electoral competition could explain the persistence of the negative sign for this variable [46]. Third, the dummy variable indicating the 2008–2009 financial crisis showed inconsistent results throughout the robustness tests. However, Monte Carlo simulations suggest the possibility of long-term effects of financial shocks on the debt sustainability indicator. After multiple robustness tests, we conclude that our results remain reliable across the various specifications through regional, temporal, and measurement differences.

Another interesting line of further research that needs to be investigated in the future is the impact of different categories of expenditure on municipalities' fiscal sustainability. Following the works by Srhoj and Dragojević [49], on the effectiveness of public procurement of construction projects on public grants for SMEs [50], and on public grants for SMEs and R&D grants [51], researchers might want to look at how the composition of expenditure could make a difference depending on how well entities cope with debt sustainability. This could be a fruitful line of research and would provide further insight into the cost-benefit analyses of exerting different forms of public spending.

The evidence for Mexico presented in this article is relevant for other emerging economies with similar political and economic structures, centralized governments, and a low capacity of subnational governments to collect taxes. The economies have increasingly opened up to the rest of the world, increasing their exposure to foreign financial and economic shocks that hinder the ability of subnational governments to maintain sustainable fiscal positions. Fiscal rules, transparency, legal accountability, and stringent measures for disciplining municipal fiscal authorities are recommended to prevent the potential unsustainable fiscal stances of municipal governments.

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