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The Effects Of Municipal Delegation Agreements On Rural Land Tax Collection In The State Of Minas Gerais

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Abstract:
This study analyzed the collection of the Rural Land Tax (Imposto Territorial Rural, ITR) in the municipalities of the state of Minas Gerais between 2000 and 2020, with emphasis on the effects of the delegation agreements signed between municipal entities and the Brazilian Federal Revenue Service. From a unified database containing information on 853 municipalities in Minas Gerais, annual collection time series were observed, standardized, and complemented with binary-coded data on whether or not an agreement had been signed. Wide variability was identified in the amounts collected over the years; in 2020, for example, collection ranged from less than R$ 1,000 to more than R$ 5 million in certain municipalities, revealing high dispersion and the presence of outliers. Because of this feature, the normality of the data distribution was tested using the Shapiro-Wilk test, histograms, and Q-Q plots. In all years analyzed, the results indicated rejection of the null hypothesis of normality, which required data-treatment procedures. Logarithmic transformations and stratification by deciles reduced skewness but did not ensure full normality. Given this scenario, non-parametric methods were adopted: to test the hypothesis that municipalities with agreements collected more after formalization (H1), the Welch-corrected t-test and the Brunner-Munzel test were used, both appropriate for independent samples with skewed distributions. The results revealed statistically significant differences between municipalities that signed an agreement with the Federal Revenue Service and those that did not. The study reinforces the importance of adapting statistical methods to the empirical characteristics of the data and suggests that decentralized fiscal policies, such as the ITR delegation agreements, may generate differentiated effects according to the economic profile of the municipalities.

Keywords: *Rural Land Tax (ITR); Fiscal decentralization; Tax collection; Municipal delegation agreements; Non-parametric tests.*

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I. Introduction

The Rural Land Tax (Imposto Territorial Rural, ITR) is a tax under the jurisdiction of the Union, pursuant to Article 153, VI of the Federal Constitution [1]. After redemocratization, the regulation of taxation on rural properties came with the enactment of the ITR Law [2]. This rule established a system of progressive rates whose application considered criteria such as territorial extension, form of occupation, and the location of the property. According to the legal text, the rates ranged from 0.02% to 4.5%, calculated on the Bare Land Value, comprising the property's value excluding the value of constructions, installations, and improvements [2,3].

Under the current Brazilian tax system, the rural land tax acts both as a revenue-collection instrument and as an extrafiscal (regulatory) instrument [4]. The tax is calculated by identifying the taxable bare land value (VTNt), composed of the quotient between the taxable area and the total area of the property, multiplied by the tax rate, according to the property's degree of utilization [3].

However, this assessment criterion entails difficulties that can be explained by structural factors that compromise its practical effectiveness, such as the understated bare land value reported by the taxpayer, the obsolescence of official rural-productivity indicators, and the negligent treatment given to environmental preservation areas [4,5].

Tax assessment, collection, and enforcement underwent a systematic change following Constitutional Amendment No. 42/2003, which introduced the possibility of creating progressive tax rates and, above all, delegated competences that belonged to the Federal Union to the municipalities. With the amendment in force, Article 37, XXII, provides that the tax administrations of the Union, the States, the Federal District, and the Municipalities are to act in an integrated manner, including through the sharing of registries and tax information, as provided by law or agreement. Article 156, §4, III, provides that the tax is to be enforced and collected by the municipalities that so choose, as provided by law, provided this does not imply a reduction of the tax or any other form of tax waiver.

The reform introduced by Constitutional Amendment No. 42/2003, regulated by infra-constitutional rules, operationalized fiscal activities and, consequently, enabled the delegation of the Union's collection and enforcement competences to the municipalities, at their option, through the signing of agreements [6,7].

The transfer of collection and enforcement competences to municipalities, through agreements signed with the Brazilian Federal Revenue Service, began in 2008, with a subsequent amendment in 2016 [8,9]. The rationale underlying decentralization rests on the premise that the municipality, being closer to the local land reality, is better positioned to adequately assess properties, detect fraudulent declarations, and correct undervaluations of the bare land value [5,10].

Currently, the delegation of competence is optional and conditioned on meeting technical and institutional requirements, which may be obstacles for smaller municipalities with limited administrative structure [5]. To sign an agreement with the Federal Revenue Service, the municipality must have technological infrastructure compatible with the federal tax administration's systems, maintain its own legislation providing for specific positions for tax-credit assessment, and have public servants hired through competitive examination for this purpose. In addition, it must adhere to the Electronic Tax Domicile (DTE), meet minimum enforcement targets, and regularly feed the Land Price System (SIPT) with updated bare-land values (VTN) [8,9].

In Brazil, idle properties largely remain beyond the reach of tax enforcement, and the mechanisms for identifying unproductiveness have not been effective in fostering expropriations or land redistribution via agrarian reform. Given this scenario, the ITR, although formally structured to produce relevant social and economic impacts, shows low performance in the regulatory functions for which it was conceived [4,10].

Nonetheless, doubts persist as to whether signing an agreement between municipalities and the Federal Revenue Service positively affects municipal ITR collection. This question is addressed by confirming or refuting the hypotheses. H1: after the agreement with the Federal Revenue Service, the municipality increased its ITR collection relative to its peers. H2: after the agreement, the municipality did not increase its ITR collection relative to its peers.

The article is structured in four sections: introduction, methodology, discussion of results, and conclusion. The introduction presents the research problem and an overview of the legislation related to the rural land tax in Brazil. The methodology section describes how the data were obtained, the variables, and the procedures adopted for their treatment. The results section discusses the findings obtained through statistical tests, with emphasis on the correlation analysis between the variables of interest. Finally, the last section presents the concluding remarks, highlighting the study's contributions, its limitations, and suggestions for future research.

II. Methodology

The exploratory data analysis of this study began with locating a database containing ITR collection by municipality over a given period. The database is suitable for the proposed objectives, since the work aims to measure the effect of the agreements signed with the Brazilian Federal Revenue Service on the historical collection value and to compare the results of municipalities with and without agreements. To this end, the hypotheses to be tested are H1: after the agreement with the Federal Revenue Service, the municipality increased its ITR collection relative to its peers; and H2: after the agreement, the municipality did not increase its ITR collection relative to its peers.

The research is classified as quantitative, given its emphasis on objectivity, systematization, and statistical rigor, its reproducibility, and its focus on a small number of clearly defined and operationalizable concepts. The approach starts from the hypotheses formulated in the introduction, seeking to verify correlations between predefined variables through structured procedures for collecting official data [11].

As for its objectives, the research is explanatory, since it seeks to confirm or reject hypotheses of correlation between ITR collection and the agreements signed with the Brazilian Federal Revenue Service [12].

Data collection and initial exploratory analysis of the collection data

ITR data were collected directly from the database of the Brazilian Federal Revenue Service [13], for the period from 2000 to 2020. This interval was selected based on the availability of individualized information on ITR collection revenues by Brazilian municipality.

The data systematized by the Federal Revenue Service are individualized by municipality and by the monetary value in reais of the accumulated collection each year. The originally available database contains two tabs in an .xls file. In the first tab, each row represents the collection of a municipality between 2000 and 2019, and each column represents a year. The second tab contains the same information for 2020. For proper use of the data, treatment and normalization were necessary, including the removal of special characters and the cross-referencing of information to consolidate a single table that could be exported to the analysis software. This table brought together the consolidated data for the 2000-2020 period, enabling initial analyses of the variation in collection over this period [13].

A general reading of the Brazilian series shows an upward trend in average collection, which rose from approximately R$ 40,000 per municipality in 2000 to about R$ 337,000 in 2020. The raw data required cleaning: between 2000 and 2007 the number of missing observations exceeded 200 (falling to between 45 and 64 from 2008 to 2020), and some negative values were present, indicating entry errors by the National Treasury, since collection cannot be negative. Because the analytical corpus is the municipalities of Minas Gerais, information on municipalities outside the state was excluded, and, since the first agreement was signed in 2008, pre-2008 data were not used.

Table 1: General overview of the Minas Gerais data, 2008-2020 (annual figures in R$)

Year	N	Mean	Median	Std. dev.	Min	Max	W	p
2008	851	62,443	15,287	189,394	1,123	2.83e6	0.297	<.001
2009	850	69,845	16,193	225,316	934	2.84e6	0.277	<.001
2010	851	87,911	17,539	342,925	797	7.55e6	0.210	<.001
2011	851	93,013	20,153	282,546	833	4.02e6	0.307	<.001
2012	852	110,859	21,881	360,126	1,134	4.65e6	0.288	<.001
2013	852	121,366	22,684	363,427	-13,614	4.15e6	0.325	<.001
2014	851	126,146	25,009	367,345	1,186	3.72e6	0.335	<.001
2015	851	139,639	29,276	384,362	1,164	4.15e6	0.361	<.001
2016	851	136,050	29,514	376,806	1,078	4.20e6	0.352	<.001
2017	851	160,898	32,571	440,694	1,101	4.14e6	0.364	<.001
2018	850	166,166	34,522	449,074	1,039	5.33e6	0.366	<.001
2019	853	199,853	39,518	576,215	0	6.96e6	0.339	<.001
2020	850	210,430	42,364	576,243	-374	6.28e6	0.363	<.001

Source: prepared by the author. W and p refer to the Shapiro-Wilk normality test.

The exploratory analysis of ITR collection between 2008 and 2020 reveals a dataset with marked heterogeneity among the municipalities of Minas Gerais, as well as a distribution that does not meet the assumptions of statistical normality.

The data show a difference between mean and median values throughout the time series, indicating a non-normal distribution. Over the period, the mean tends to grow: in 2008 the average collection per municipality was R$ 62,443, while in 2020 it was R$ 210,430. The median rose from R$ 15,287 in 2008 to R$ 42,364 in 2020. This behavior is characteristic of distributions with a long right tail, in which a few extreme values distort the mean and reduce its representativeness as a measure of central tendency.

The pronounced dispersion of the data is also evident from the standard deviations, which range from R$ 189,394 in 2008 to R$ 576,243 in 2020, and from box-plot inspection, which reveals numerous high-value outliers well above a low-valued central mass, evidencing marked variation among municipalities in tax collection.

The Shapiro-Wilk normality test confirmed, in a statistically significant way, that the data do not follow a normal distribution. The W statistic ranges from 0.210 to 0.366 over the period, while the p-value remains below 0.001. These robust results authorize rejection of the null hypothesis of normality for all years analyzed.

Exploratory analysis of the agreement data

Data on the agreements signed by the municipalities of Minas Gerais were collected from the website of the Brazilian Federal Revenue Service. The data are classified according to the status of the agreement, such as agreement requested, agreement signed, agreement published, agreement in force, termination requested, termination filed by the RFB, termination in force, agreement granted, agreement denied, agreement signed by the SRF, and request waived [14].

Table 2: Status of the RFB agreement in the municipalities of Minas Gerais

Agreement status	Count	% of total	Cumulative %
Agreement signed	17	4.1%	4.1%
Agreement denied	95	23.1%	27.2%
Agreement requested	1	0.2%	27.4%
Agreement in force	129	31.3%	58.7%
Termination in force	145	35.2%	93.9%
Request waived	25	6.1%	100.0%

Source: prepared by the author from Federal Revenue Service data.

Of the total municipalities in Minas Gerais, 412 requested the signing of an agreement with the Federal Revenue Service; of these, 17 have a signed agreement, 129 have an agreement in force, 145 have a termination in force, 95 had their request denied, and 25 waived the request [14].

This study focuses on the municipalities with an agreement in force. For data treatment and statistical analysis, a binary variable was created for standardization, in which the value 1 represents an affirmative answer to "agreement in force" and the value 0 represents a negative answer. After manually checking the variable, the databases were unified.

Comparative analysis of municipalities with and without agreements

The table below presents the composition of two comparative analysis groups: municipalities that adhered to the agreement and municipalities that did not.

Table 3: Comparative mean and median collection by agreement group (R$)

Year	Mean (no agr.)	Mean (agr.)	Median (no agr.)	Median (agr.)
2008	29,269	248,114	12,607	94,685
2009	29,505	295,315	12,804	112,077
2010	39,395	359,449	13,746	127,642
2011	39,713	391,329	16,082	155,268
2012	49,759	453,304	17,712	191,375
2013	59,017	470,810	18,006	232,496
2014	50,733	548,224	19,690	242,974
2015	61,096	579,239	21,982	274,583
2016	56,662	580,375	23,279	264,860
2017	62,098	713,870	25,645	358,784
2018	63,448	740,273	26,977	389,034
2019	72,360	915,397	31,435	416,018
2020	78,947	945,303	32,945	456,823

Source: prepared by the author. Group sizes: approximately 722 municipalities without an agreement and 129 with an agreement in force.

The mean collection in municipalities with an agreement is higher than in those without. In 2010, for instance, the mean among municipalities with an agreement was R$ 359,449, whereas those without averaged only R$ 39,395. This difference persists throughout the series, reaching, in 2020, means of R$ 945,303 for municipalities with an agreement and R$ 78,947 for those without. The difference in means is a first indication that formalizing the agreement acts as an important factor in increasing collection.

The median collection is also higher in municipalities with an agreement, reaching R$ 456,823 in 2020 for those with an agreement and R$ 32,945 for those without.

A comparison of the quartiles reinforces this gap even in the lower bands of the distribution. In 2015, for example, the first quartile (Q1) was R$ 74,713 for municipalities with an agreement against R$ 9,343 for those without, and the third quartile (Q3) reached R$ 799,038 against R$ 50,349, respectively.

These data suggest that adherence to the agreement is associated with an increase in ITR collection, both in the central values (median) and in the upper bands of the distribution. In addition, the increase in the standard deviation among municipalities with an agreement indicates that, despite the average growth, there is significant heterogeneity among them, possibly arising from factors such as population size, territorial extension, agricultural activity, and local administrative capacity. Adherence to the agreement should therefore be regarded as a relevant strategy for strengthening the financial autonomy of local entities, especially in the context of recent discussions on tax reform and the decentralization of fiscal competences.

To test the normality of the stratified series, the Shapiro-Wilk test was applied to both groups. In all periods, the p-values were below 0.001 for both groups, meaning that the null hypothesis of a normal distribution must be rejected. This finding is corroborated by the W statistics, which remain far from 1, indicating strong skewness or the presence of relevant outliers.

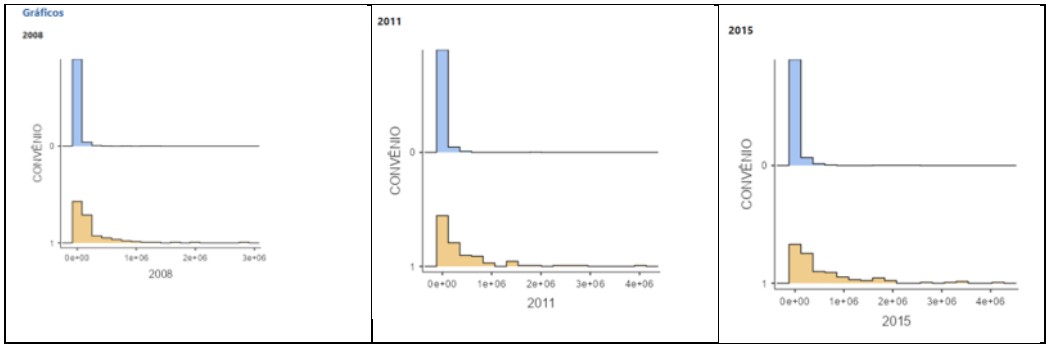

Figure 1: Data distribution histograms (2008, 2011, and 2015)

The histograms for 2008, 2011, and 2015 also show right skewness, especially among municipalities without an agreement. The shape of the distribution indicates a high concentration of municipalities with collection values close to zero, contrasting with a few cases of very high values. This behavior is characteristic of long-tailed distributions, which reinforces the inadequacy of parametric tests without prior data transformation or robust approaches.

In this context, the violation of normality restricts the application of classic parametric tests (such as the Student t-test for means), making it advisable to use non-parametric tests that do not assume a normal distribution.

Procedures adopted to promote normality of the data distribution

Normality of the data distribution is a prerequisite for applying parametric tests [15-17]. The analyses and tests showed that the database does not present a normal distribution of the ITR collection variable, a conclusion drawn from the histograms, box-plots, and the Shapiro-Wilk test. This subsection discusses the application of data transformations to bring the distribution closer to normality.

As a first normalization technique, the data were stratified into deciles in an attempt to standardize the collected data.

The analysis of the ITR collection distribution, after stratification by percentiles from the 10th to the 90th, reveals that even the stratified data are not normally distributed [18]. The measure of central tendency lies considerably far from the upper bands, particularly among municipalities that signed an agreement with the Federal Revenue Service. Although percentile stratification was efficient in mitigating the effects of extreme values and enabling a more robust analysis of central tendency and dispersion, the data remain incompatible with statistical models that require normality as an assumption.

The Shapiro-Wilk test applied to the decile-stratified series again rejected the hypothesis of normality for both municipalities with and without an agreement. In all years analyzed, the p-values were below 0.001. The W statistics ranged from 0.155 to 0.439 for municipalities without an agreement and from 0.412 to 0.754 for those with one, reinforcing the presence of skewness. This absence of normality was confirmed throughout the series, justifying the adoption of non-parametric statistical tests in the comparisons between groups.

III. Results

Non-parametric analysis of the data

The Student t-test for independent samples was initially employed to verify whether there were statistically significant differences in the mean ITR collection between the two groups of municipalities, those with an agreement with the Federal Revenue Service and those without. The t-test is a classic parametric technique for comparing the means of two independent groups, under the assumptions of normality of the distributions and homogeneity of variances [15-18]. Applied to the data, it returned t statistics between 10.4 and 18.7, always with p-values below 0.001, allowing rejection of the null hypothesis of equal means (H0: $\mu_0 = \mu_1$) in favor of the alternative (H1: $\mu_0 \neq \mu_1$) at the 1% level.

However, from the initial analyses it was evident that the ITR collection data present a skewed distribution, with outliers and a high standard deviation. In addition, the Levene test, applied as a prerequisite for the t-test, was significant ($p < 0.05$) for all years analyzed, with F statistics ranging from 151 to 580, indicating a violation of the assumption of homogeneity of variances [19]. This violation compromises the validity of the classic equal-variances model, so the calculations were performed using the Welch correction, which adjusts the degrees of freedom and makes the test robust to the heteroscedasticity observed between the groups.

Welch correction

The Welch correction was necessary because of the violation of the homogeneity-of-variances assumption, previously identified through the Levene test. This violation would compromise the validity of the traditional t-test, making the Welch approach more appropriate for the analyzed context.

Table 4: Welch-corrected t-test

Year	Statistic (t)	df	p
2008	-6.16	130	<.001
2009	-6.10	129	<.001
2010	-4.67	129	<.001
2011	-6.52	129	<.001
2012	-6.51	132	<.001
2013	-6.73	132	<.001
2014	-7.45	130	<.001
2015	-7.69	130	<.001
2016	-7.69	130	<.001
2017	-8.28	129	<.001
2018	-8.29	129	<.001
2019	-7.84	129	<.001
2020	-8.23	129	<.001

Source: prepared by the author. Two-sided H1: $\mu_0 \neq \mu_1$; one-sided H1: $\mu_0 < \mu_1$ (same statistics, all $p < .001$).

The negative direction of the t statistics in all years implies that municipalities with an agreement had higher mean collection than those without, since the "with agreement" group was coded as the second sample (group 1) in the comparison. The empirical evidence is therefore favorable to hypothesis H1, according to which signing an agreement with the Federal Revenue Service favors an increase in municipal ITR collection.

The increasing magnitude of the t statistics from 2014 onward suggests a deepening of the differences between the groups. Although the t-test is traditionally sensitive to departures from normality, the Welch correction minimizes this impact, allowing reliable results even in the presence of skewness in the collection distributions.

Under the one-sided formulation, in which the alternative hypothesis states that the mean collection of municipalities without an agreement (μ_0) is lower than that of municipalities with an agreement (μ_1), that is, H1: $\mu_0 < \mu_1$, the t statistics ranged in absolute value between 4.67 and 8.29, with all p-values below 0.001. This confirms, with robust statistical significance, the superiority of the mean collection of municipalities with an agreement.

Brunner-Munzel test

The application of the Brunner-Munzel test to the ITR collection data, stratified between municipalities with and without an agreement, revealed statistically robust results for the comparison between independent groups.

Table 5: Brunner-Munzel test

Year	Statistic	df	p
2008	23.6	179	<.001
2009	23.6	176	<.001
2010	21.6	176	<.001
2011	20.8	167	<.001
2012	23.7	176	<.001
2013	22.7	179	<.001
2014	23.4	168	<.001
2015	24.0	170	<.001
2016	24.0	167	<.001
2017	25.4	163	<.001
2018	26.6	164	<.001
2019	25.2	158	<.001
2020	25.0	160	<.001

Source: prepared by the author. Ha: $P(Y_0 < Y_1) + \frac{1}{2} \cdot P(Y_0 = Y_1) > \frac{1}{2}$.

Over the thirteen years from 2008 to 2020, all test values showed significance levels below 0.001, denoting, with a high degree of statistical confidence, rejection of the null hypothesis. In the Brunner-Munzel test, the null hypothesis assumes that there is no stochastic superiority between the distributions of the two groups, that is, that the probability of a municipality with an agreement collecting more than one without an agreement would be 50%.

In all years analyzed, the test returned statistic values between 20.8 and 26.6, with degrees of freedom (df) varying between 158 and 180 according to the number of valid observations for each year. In all cases, the observed p-values were below 0.001.

The alternative hypothesis was formulated in one-sided terms: the probability that a municipality without an agreement (group 0) presents lower collection than a municipality with an agreement (group 1), plus half the probability of equal collection between the groups, is greater than 50%. Formally, Ha: $P(Y_0 < Y_1) + ½ \cdot P(Y_0 = Y_1) > ½$.

Although the test does not provide a direct estimate of the effect size, the substantial statistic values throughout the period suggest that the difference between the groups is not only statistically significant but also substantive. This supports the interpretation that adherence to the agreement with the Federal Revenue Service is associated with an improvement in ITR collection levels compared with the performance of municipalities that chose not to sign the instrument.

Correlation analysis

The final stage of the empirical investigation involved correlation tests to verify whether there is a statistically significant association between the existence of an agreement with the Federal Revenue Service and the ITR amounts collected by the municipalities of Minas Gerais from 2000 to 2020. The "agreement" variable was binary-coded (1 for municipalities with an agreement and 0 for the others), while the collection variables retained their continuous nature. The Spearman and Kendall tau-b correlations were applied.

The Spearman coefficient assesses the monotonic correlation between two ordinal or quantitative variables, without assuming a linear relationship or normal distribution. In this research, it allowed verification of whether municipalities with an agreement systematically presented higher (or lower) collection than those without, without requiring linearity or homoscedasticity. Complementarily, Kendall's tau-b also measures monotonic associations, but is based on the count of concordant and discordant pairs.

The results indicated positive correlations of moderate magnitude, with statistical significance in practically all years analyzed. In 2020, for example, the observed correlation was $r = 0.377$, with $p < 0.001$, revealing a tendency for municipalities with an agreement to present higher ITR collection than those that did not sign the agreement. This pattern was consistent across the years, with small variations in the correlation coefficients.

The correlation results function as a complementary extension of the previous tests. Whereas the Welch-adjusted t-test and the Brunner-Munzel test attested to the existence of differences between the groups, the correlation quantifies the intensity and direction of the association between the agreement and the level of collection. The convergence between the methods strengthens the interpretation that there is a positive relationship between institutional cooperation with the Federal Revenue Service and the increase in the collection capacity of municipal entities.

It should be noted, however, that this association, although statistically significant, does not allow causal inference. Structural, administrative, and territorial aspects of the municipalities may simultaneously influence both the decision to sign an agreement and the collection levels, acting as confounding variables. Therefore, although the empirical findings support hypothesis H1, that municipalities with an agreement collect more than their peers, this inference must be considered in light of the methodological limitations and the exploratory nature of the study.

IV. Conclusion

This study sought to assess the effects of decentralizing the enforcement of the Rural Land Tax (ITR) through the agreements signed between municipalities and the Brazilian Federal Revenue Service (RFB), as well as to examine the relationship between municipal territorial extension and the collection capacity associated with this tax. To this end, the following hypotheses were tested. H1: after the agreement with the Federal Revenue Service, the municipality increased its ITR collection relative to its peers. H2: after the agreement, the municipality did not increase its ITR collection relative to its peers.

The study aimed to verify whether signing an agreement with the Federal Revenue Service for the enforcement and collection of the ITR by the municipalities of Minas Gerais led to a significant increase in collection relative to their peers without an agreement. The analysis focused on collection data between 2008 and 2020, comparing groups of municipalities with and without an agreement through statistical methods appropriate to the non-parametric nature of the database.

The results consistently indicated differences in collection between the groups. Although the data distribution was not normal, even after attempts at transformation through stratification, outlier exclusion, and grouping, the non-parametric tests applied revealed clear result patterns. These findings support the interpretation that adherence to the agreement with the Federal Revenue Service is associated with an improvement in ITR collection levels compared with the performance of municipalities that chose not to sign the instrument.

The Spearman correlation, in turn, identified a positive and significant correlation between having an agreement and the amount collected in several years. Despite the statistically significant findings, some limitations of the study should be highlighted. The database, although broad, presents strong skewness and the presence of extreme values, which hindered the application of more robust parametric tests. In addition, structural variables such as territorial area, agricultural profile, and administrative capacity of the municipalities were not included, which limits causal inference about the effect of the agreement.

For future studies, it is recommended to expand the model through multivariate regression techniques that can control for intervening variables. It would also be relevant to include qualitative dimensions on the execution of the agreement and the degree of effectiveness of decentralized enforcement, which would contribute to a more comprehensive evaluation of the public policy under analysis.

In summary, the work showed that, even with methodological limitations, the agreement with the Federal Revenue Service is associated with superior ITR collection performance, signaling its importance as an instrument for strengthening municipal tax management.

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