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Research Article

Tax Simplification and Business Formalization in Colombian Caribbean Cities

Mildred Eugenia Garizabal Donado[1]*, Luz Eliana Garizabal Donado[2], Luis Fernando Ospino Arias[1] and Aydaluz Villanueva Vásquez[1]

[1] *Institución Universitaria de Barranquilla, Colombia.*

[2] *Universidad de la Costa, CUC, Colombia.*

*Corresponding author: Mildred Eugenia Garizabal Donado, Institución Universitaria de Barranquilla, Colombia. Email: migarizabal@unibarranquilla.edu.co

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Abstract: The objective of this study was to examine whether greater adoption of Colombia's Simple Taxation Regime was associated with subsequent changes in multidimensional business informality in Barranquilla, Cartagena, Santa Marta, and Valledupar, while distinguishing participation in a simplified tax regime from substantive business formalization. A balanced quarterly synthetic panel covering 2021Q1–2024Q4 was calibrated to verified annual benchmarks published by the Colombian tax authority and the national statistical agency. The resulting dataset contained 64 city-quarter observations. Calibration consistency and median absolute deviation screening were used as data-verification procedures. The study hypothesis was examined through lagged Spearman correlation, two-way fixed-effects models, and first-difference estimations, with unemployment and service-sector composition included as limited time-varying controls. Calibration discrepancies remained small, while anomaly screening identified four unusually rapid transitions that were retained for analysis. Lagged Spearman and first-difference estimates were generally negative but statistically imprecise. In contrast, fixed-effects coefficients were positive and close to conventional significance thresholds, indicating that the estimated relationship was sensitive to the source of within-city variation used in each specification. The calibrated evidence does not establish a stable association between greater RST intensity and lower multidimensional business informality. Tax-regime uptake, fiscal registration, and broader organizational formalization appear to be related but distinct processes whose trajectories may differ across territories and periods. The study separates simplified-tax participation from substantive formalization and evaluates one hypothesis through complementary longitudinal procedures. It also provides a replicable analytical framework that can later be applied to linked administrative data.

Keywords: Tax simplification, Business formalization, Informal economy, Small and medium-sized enterprises, Colombia

JEL Classification: H25, H26, L26, O17

1. Introduction

Business informality is frequently associated with taxation, administrative complexity, regulatory burdens, and relatively high compliance costs. These factors can be especially relevant for micro and small enterprises because many compliance obligations contain fixed-cost components that represent a larger share of their available administrative resources. Businesses may need to maintain accounting records, comply with tax calendars, interpret regulatory changes, use digital platforms, obtain professional advice, and interact with several public institutions. Simplified taxation may reduce some of these burdens and thereby improve the relative attractiveness of formal participation. Nevertheless, the relationship is unlikely to be automatic. Formalization decisions can also depend on productivity, firm size, access to markets, managerial capabilities, financial inclusion, perceived institutional benefits, and expectations about enforcement. Alm and McClellan [1] indicate that firm-level tax compliance is influenced by institutional and behavioral considerations in addition to statutory rates, while Wen [2] argues that simplified presumptive taxation can be particularly relevant where compliance costs impose substantial burdens on micro and small enterprises. In Colombia, these issues operate alongside persistent regional differences in productivity and informality [3]. Consequently, a relevant empirical question is not simply whether simplified taxation reduces administrative complexity, but whether greater participation in such regimes tends to be followed by observable improvements in broader dimensions of business formality.

Colombia's Régimen Simple de Tributación (RST) provides an appropriate institutional context for exploring this question. The regime consolidates several tax obligations, modifies payment timing, reduces certain withholding pressures, encourages digital interaction with the tax administration, and integrates national and territorial components of taxation. These features may lower some of the administrative frictions associated with formal participation. However, several mechanisms could weaken the relationship between RST enrollment and deeper formalization. Firms that were already formal may change from the ordinary tax regime to the RST without modifying their underlying organizational practices. Some low-productivity informal businesses may remain outside the formal sector even when compliance becomes easier. Other firms may register for tax purposes while continuing to use informal labor or incomplete accounting practices. McKenzie and Sakho [4] show that the economic returns to tax registration can differ considerably across firms, and La Porta and Shleifer [5] emphasize structural differences in productivity and entrepreneurial characteristics between many formal and informal enterprises. These findings

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suggest that simplified taxation may represent one possible component of a broader formalization process rather than a sufficient condition for that process.

This study examines whether increases in RST intensity are associated with subsequent changes in multidimensional business informality in four Colombian Caribbean cities: Barranquilla, Cartagena, Santa Marta, and Valledupar. The analysis separates RST participation from the formalization outcome rather than treating tax registration itself as evidence of formalization. A quarterly synthetic panel covering 2021Q1–2024Q4 was calibrated to verified annual benchmarks reported by the Colombian tax authority and DANE. The resulting dataset contains 64 city-quarter observations. Two procedures assess the consistency of the calibrated information, while the study hypothesis is examined through three complementary approaches: lagged Spearman correlation, two-way fixed-effects estimation, and first differences. These methods do not provide equivalent forms of evidence. The Spearman analysis evaluates temporal monotonic association; fixed effects examine variation within cities after accounting for relatively stable territorial characteristics and common time effects; and first differences focus on short-run changes within the same city. Because the quarterly data are synthetically calibrated rather than administrative microdata, the findings are interpreted as evidence about the plausibility and stability of the proposed relationships rather than as definitive causal estimates.

2. Theoretical or Conceptual Framework

Compliance costs and simplified taxation

Tax compliance involves substantially more than the payment of a statutory tax liability. Firms generally need to identify applicable obligations, maintain records, prepare declarations, update accounting systems, monitor legal changes, and allocate managerial resources to regulatory tasks. Many of these activities generate costs independently of the amount of tax ultimately paid. When a portion of these costs is fixed, the proportional burden can become particularly relevant for smaller firms. Slemrod and Venkatesh [6] document the importance of business tax-compliance costs and illustrate why administrative obligations may impose uneven burdens across firm sizes. Bird and Zolt [7] similarly argue that taxation in emerging economies should be evaluated not only through statutory rates but also through administrative capacity, implementation requirements, and the characteristics of taxpayers.

This reasoning provides a potential link between simplified taxation and formalization. A firm considering formal participation compares expected benefits from formal operation with fiscal obligations, administrative requirements, and other regulatory costs. If simplified taxation reduces part of the fixed cost of compliance, the relative net benefit of formal operation may improve. The relevant mechanism is therefore broader than a lower nominal tax rate. Simplification can reduce uncertainty about obligations, improve the predictability of payments, facilitate record keeping, and reduce the number of separate interactions required with tax authorities. Wen [2] argues that presumptive and simplified tax systems may be useful where conventional tax structures impose relatively high compliance demands on micro and small enterprises. OECD et al. [8] likewise treat administrative simplification as one element within a broader SME-policy framework involving digitalization, business development, finance, and institutional capacity.

Simplification can also interact with monitoring and information. Greater reliance on electronic invoicing, digital payments, standardized reporting, and integrated tax records may make compliance more manageable while increasing the traceability of transactions. Pomeranz [9] shows that information structures and third-party reporting can affect tax enforcement and compliance incentives. Alm and McClellan [1] additionally suggest that tax compliance reflects perceptions of institutions and tax morale. These perspectives imply that simplified taxation may influence firms through several overlapping channels: reduced transaction costs, improved predictability, greater information traceability, and a potentially more accessible relationship with tax institutions. The relative importance of each channel is likely to vary across firms and territories.

Formalization as a heterogeneous decision

A substantial literature cautions against assuming that all informal firms would prefer formal status if registration became less costly. McKenzie and Sakho [4] find heterogeneous profitability effects associated with tax registration. Some businesses may obtain greater legitimacy, market access, or commercial opportunities from registration, while others may receive more limited benefits relative to the fiscal and administrative obligations they assume. Formalization can therefore depend on where a firm lies relative to an economic threshold at which formal participation becomes worthwhile.

Experimental research provides additional evidence of this heterogeneity. de Mel et al. [10] find that providing information and reimbursing registration expenses generated limited formalization among informal firms in Sri Lanka, whereas larger financial incentives produced stronger registration responses. Even among firms that formalized, subsequent gains were not uniform. These findings suggest that administrative barriers can matter without necessarily constituting the primary constraint for every enterprise. Simplified tax regimes may therefore have stronger effects among businesses whose productivity, scale, or market orientation already place them relatively close to formal operation.

La Porta and Shleifer [5] develop a related structural argument. Their interpretation of informality emphasizes differences in productivity, human capital, business scale, and managerial characteristics. Some informal enterprises may therefore remain economically distinct from typical formal firms even when registration procedures become easier. Ulyssea [11] similarly concludes that reductions in the costs of formality can contribute to formalization but may be insufficient when other structural constraints remain important. This literature suggests that the relationship between tax simplification and formalization should be expected to vary across businesses and should therefore be tested as a conditional empirical relationship rather than assumed in advance.

Latin American evidence on simplified taxation

Latin American tax reforms provide relevant evidence on the possible relationship between simplification and business

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formalization. Fajnzylber et al. [12] examine Brazil's SIMPLES program and report evidence consistent with improvements in several dimensions of formality among eligible microenterprises. Their findings also suggest changes in revenues, employment, and capital intensity among some newly formal businesses. This evidence indicates that lowering tax and administrative burdens can potentially influence business organization in addition to registration behavior.

The results from Brazil nevertheless appear heterogeneous. Monteiro and Assunção [13] find stronger formalization effects among eligible retail establishments than in several other economic activities. This suggests that the consequences of simplified taxation can depend on sector characteristics. Businesses differ in profit margins, cost structures, labor intensity, seasonality, and their ability to benefit from formal market access. These differences are relevant for Colombia's RST because rates and potential advantages vary across economic activities and income brackets.

Rocha et al. [14] provide additional evidence that lower taxes can encourage some informal firms to formalize even after administrative registration costs have been reduced. However, the magnitude of these responses appears sufficiently moderate to make the cost-effectiveness of tax incentives an important consideration. Ulyssea [15] further distinguishes between extensive and intensive dimensions of informality. A business can possess formal registration while retaining informal workers or incomplete reporting practices. This distinction provides an important reason not to use RST registration itself as the dependent measure of formalization. A multidimensional indicator offers a more demanding assessment of whether tax-regime participation is associated with broader organizational changes.

Theoretical mechanism and research hypothesis

The literature supports a possible sequence through which simplified taxation may contribute to formalization. First, the regime may reduce some administrative and fiscal frictions associated with remaining formally registered. Second, a lower compliance burden may modestly improve the expected net benefits of formal participation. Third, formal operation can facilitate electronic invoicing, banking relationships, contracting, and improved business records. If these mechanisms are sufficiently relevant for a meaningful share of firms, increases in simplified-tax participation could eventually be accompanied by reductions in broader measures of business informality.

However, the same literature identifies several reasons why this association may be limited or delayed. Firms with very low productivity may continue to find informal operation economically preferable. Already-formal firms can shift from the ordinary regime into the RST without generating additional formalization. Labor practices may remain informal after tax registration, while technological requirements may create new difficulties for some microenterprises. OECD [3] emphasizes persistent territorial and productivity differences in Colombia, and OECD et al. [8] highlight the relevance of complementary SME capabilities. These considerations suggest that the relationship may become more informative when changes are observed within cities over time rather than through simple cross-sectional comparisons.

Accordingly, the study evaluates one hypothesis: H1 proposes that greater RST intensity is associated with a subsequent reduction in multidimensional business informality. Because higher IMIE values denote greater informality, evidence consistent with H1 would generally be reflected in a negative estimated relationship. This wording is deliberately moderate. The hypothesis does not assume that RST participation necessarily produces formalization; it examines whether the observed direction and timing of the association are compatible with the proposed mechanism. The three statistical approaches examine different forms of variation. A negative association that remains reasonably stable across lagged correlation, fixed effects, and first differences would provide stronger support than a relationship appearing under only one specification.

3. Methodology

Research design

The empirical framework uses a balanced quarterly panel covering Barranquilla, Cartagena, Santa Marta, and Valledupar from 2021Q1 to 2024Q4. These cities belong to Colombia's Caribbean region but differ in economic size, sector composition, labor-market characteristics, and institutional environment. Holding national taxation broadly constant while examining different regional economies provides a useful setting for studying whether local movements in RST participation correspond to movements in business informality.

Each city contributes sixteen quarterly observations, yielding a total of 64 city-period observations. The design is longitudinal because the principal question concerns changes within cities and temporal ordering. The quarterly values are synthetically generated but calibrated against verified annual benchmarks. Consequently, the study should be interpreted as a calibrated empirical exercise rather than as an analysis of official quarterly administrative microdata. The design is useful for evaluating the statistical framework and the stability of the hypothesized relationship, while stronger substantive conclusions would require direct administrative observations.

Variable construction

The principal explanatory measure is RST intensity per 1,000 formal firms. Within the analysis, it is calculated as $RSTIntensity\_it = (RSTRegistrations\_it / FormalFirms\_it) \times 1{,}000$. Normalizing the number of registrations is important because raw enrollment is strongly influenced by the overall size of each city's business population. Barranquilla, for example, would be expected to have more registered taxpayers than a smaller urban economy even if relative RST penetration were similar.

Regression specifications use the natural logarithm of RST intensity. The dependent variable is multidimensional business informality, represented by IMIE, where higher values indicate greater informality. For interpretation, a complementary formalization measure is constructed as $100 - IMIE$. Unemployment and the share of service-sector activity are included as time-varying controls. These controls should not be interpreted as eliminating all sources of confounding; they provide a limited adjustment for

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plausible changes in local economic conditions that may be related to both formalization and RST participation.

Data verification procedures

The first verification examines how closely the calibrated quarterly series correspond to the official annual anchors. For RST, fourth-quarter observations are compared directly with the annual DIAN benchmark. The discrepancy is calculated as the proportional difference between the calibrated Q4 value and the corresponding annual value. IMIE is treated somewhat differently because quarterly variation is intentionally introduced around the annual DANE benchmark. The mean of the four quarterly values is therefore compared with the annual reference level.

The second verification procedure applies the median absolute deviation to changes in logged RST intensity. For each quarter-to-quarter change, a robust standardized score is calculated using $0.6745 \times (x - \text{median}) / \text{MAD}$. Values with an absolute score greater than 3.5 are flagged for review. These flags are not automatically treated as errors. Rapid changes can reflect the interpolation needed to reach substantially different annual anchors or, in observed data, potentially correspond to policy changes or registration campaigns. The procedure is therefore primarily intended to identify influential or unusual transitions requiring additional examination.

Statistical analysis

The first test of H1 uses Spearman's rank correlation between previous-quarter RST intensity and the subsequent quarterly change in IMIE. The lag introduces temporal ordering and reduces dependence on contemporaneous correlation. Because Spearman's rho uses ranks, it is less sensitive to nonnormal distributions and extreme values than Pearson correlation. A negative coefficient is directionally compatible with H1.

The second procedure estimates two-way fixed-effects models of IMIE on logged RST intensity, city effects, and period effects. The model can be represented within the text as $IMIE\_it = \beta \ln(RSTIntensity\_it) + \gamma X\_it + \alpha\_i + \lambda\_t + \varepsilon\_it$. The third procedure uses first differences, represented as $\Delta IMIE\_it = \beta \Delta \ln(RSTIntensity\_it) + \gamma \Delta X\_it + \lambda\_t + \varepsilon\_it$. Fixed effects account for relatively stable differences between cities, while first differences focus directly on quarter-to-quarter changes within the same city. Because the data are synthetically calibrated and the number of cities is small, estimated coefficients and confidence intervals are interpreted cautiously.

4. Results

Calibration and statistical verification

The calibration procedure indicates that the quarterly synthetic structure remains close to the annual empirical benchmarks. RST fourth-quarter observations reproduce their corresponding annual anchor by construction, producing no closing-point discrepancy. For IMIE, the mean absolute discrepancy between annual calibrated averages and the annual benchmarks is approximately 0.268 percentage points. The maximum observed discrepancy is below half a percentage point.

Table 1. Calibration and robust verification results

City	RST discrepancy mean (%)	IMIE discrepancy mean (pp)	Maximum IMIE discrepancy	MAD flags (n)
Barranquilla	0.000	0.318	0.466	2
Cartagena	0.000	0.272	0.383	0
Santa Marta	0.000	0.285	0.426	1
Valledupar	0.000	0.197	0.412	1
Overall	0.000	0.268	0.466	4

Note. RST discrepancy compares calibrated fourth-quarter values with the corresponding annual anchors. IMIE discrepancy compares the average of quarterly calibrated observations with the annual benchmark. MAD flags identify changes in ln(RST intensity) for which |robust z| > 3.5.
Source: Authors' own work.

MAD screening identifies four comparatively unusual changes in RST intensity. Two occur in Barranquilla, while Santa Marta and Valledupar contain one flagged transition each. Cartagena contains no flagged observation under the selected threshold. These values remain in the analysis because the verification procedure does not establish that they are erroneous.

The result suggests that the synthetic series broadly retains its intended relationship with the annual empirical anchors while preserving meaningful short-run variation. Nevertheless, calibration accuracy should not be interpreted as evidence that the simulated quarterly trajectories reproduce actual quarterly administrative behavior. The procedure instead provides a consistency check for the analytical dataset.

Cross-city patterns

Mean RST intensity differs across the four cities. Barranquilla records the highest average value at 75.780 registrations per 1,000 formal firms, followed closely by Cartagena at 74.815. Santa Marta records 62.355 and Valledupar 55.756. The overall panel average is 67.177.

Table 2. Descriptive statistics by city

City	N	RST intensity Mean	RST intensity SD	IMIE Mean	IMIE SD	Formalization index mean	Unemployment mean (%)
Barranquilla	16	75.780	33.663	96.032	0.442	3.968	11.047
Cartagena	16	74.815	28.571	97.253	0.399	2.747	10.391
Santa Marta	16	62.355	25.910	97.665	1.437	2.335	12.867

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Valledupar	16	55.756	21.443	93.603	0.805	6.397	13.393
Overall	64	67.177	28.392	96.138	1.809	3.862	11.925

Note. RST intensity is measured as registrations per 1,000 calibrated formal firms. The formalization index equals 100 − IMIE. Quarterly observations are synthetic calibrated values.

Source: Authors' own work.

The descriptive ordering illustrates why cross-sectional comparisons alone would provide limited evidence about H1. Valledupar has the lowest average RST intensity but also the lowest average IMIE. Conversely, Santa Marta records comparatively high business informality despite stronger average RST intensity than Valledupar. These differences may reflect structural characteristics rather than the effects of tax-regime participation.

The longitudinal methods are therefore more informative for the study hypothesis. Fixed-effects models evaluate whether changes around each city's own average are associated with changes in informality after accounting for common time effects. This approach reduces, although does not eliminate, the possibility that persistent territorial differences are driving the results.

Lagged Spearman analysis

The pooled Spearman correlation between previous-quarter RST intensity and the subsequent quarterly change in IMIE is −0.154. The associated p value is .241. The coefficient is negative, which is directionally consistent with H1, but its magnitude is relatively small and the statistical uncertainty remains substantial.

Table 3. Lagged Spearman correlations

Sample	N	Spearman rho	p value	Direction
Barranquilla	15	−0.107	.704	H1-consistent
Cartagena	15	−0.236	.398	H1-consistent
Santa Marta	15	−0.307	.265	H1-consistent
Valledupar	15	0.068	.810	Opposite
Pooled	60	−0.154	.241	H1-consistent

Note. Predictor = previous-quarter RST intensity. Outcome = subsequent quarterly change in IMIE. Negative coefficients are directionally compatible with H1.

Source: Authors' own work.

Three of the four cities produce negative estimates. Santa Marta has the largest negative coefficient, followed by Cartagena and Barranquilla. Valledupar shows a small positive association. None of the city-specific estimates reaches conventional levels of statistical significance.

These results may be described as modest directional evidence rather than confirmation of H1. One possible interpretation is that the relationship, if present, operates only for certain firms or becomes visible over longer periods than one quarter. Another possibility is that aggregate RST intensity is an imperfect proxy for genuinely new formalization because some participants may have been formal before changing tax regimes.

Fixed-effects and first-difference models

The two-way fixed-effects models produce coefficients that differ from the direction observed in the lagged correlation. Without additional controls, the estimated coefficient on ln(RST intensity) is 4.044 with a robust standard error of 2.158 and p = .061. With unemployment and service-sector composition included, the coefficient is 4.238, with SE = 2.212 and p = .055.

Table 4. Panel estimates of multidimensional business informality

Specification	RST coefficient	Robust SE	95% CI lower	95% CI upper	p	N
Two-way fixed effects	4.044	2.158	−0.185	8.273	.061	64
Two-way FE + controls	4.238	2.212	−0.098	8.574	.055	64
First difference	−0.583	2.954	−6.374	5.207	.843	60
First difference + controls	−0.220	2.948	−5.998	5.559	.941	60

Note. Fixed-effects models use ln(RST intensity) and include city and period effects. First-difference models use Δln(RST intensity). Positive coefficients correspond to higher IMIE values and are therefore inconsistent with the expected direction of H1.

Source: Authors' own work.

The positive coefficients in the fixed-effects models should be interpreted cautiously. They do not necessarily imply that greater RST participation increases informality. Several alternative mechanisms may generate this pattern. RST enrollment may increase more rapidly during periods in which policymakers place greater emphasis on difficult-to-formalize territories. Already-formal firms may switch into the RST without producing a corresponding movement in the broader informality indicator. It is also possible that changes in organizational formalization take longer to emerge than changes in tax registration.

The first-difference estimates return to negative coefficients but with wide confidence intervals and high p values. The controlled first-difference model produces a coefficient of −0.220. This result is compatible with the expected direction but provides little statistical precision. The variation in coefficient sign across specifications suggests that the estimated relationship is sensitive to the source of identifying variation. Accordingly, the current evidence does not provide a sufficiently stable basis for asserting that greater RST intensity is systematically associated with lower multidimensional informality.

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5. Discussion

Tax participation and substantive business formalization

A central implication of the analysis is that participation in a simplified tax regime and substantive business formalization should probably be treated as related but distinct processes. RST enrollment represents participation in a particular tax framework. Fiscal formalization can additionally involve obtaining or maintaining tax registration and reporting obligations. Broader business formalization may involve registered employment, consistent bookkeeping, banking activity, electronic invoicing, contractual capacity, and organizational continuity.

This distinction can help interpret the mixed statistical results. La Porta and Shleifer [5] suggest that structural differences between many formal and informal firms extend beyond registration costs. McKenzie and Sakho [4] similarly report heterogeneous returns to tax registration. Simplified taxation may therefore be relatively useful for businesses that already possess characteristics making formal participation economically valuable, while producing smaller changes among lower-productivity firms.

For that reason, counts of RST registrations should probably be interpreted as an indicator of regime uptake rather than as a complete measure of formalization success. A broader evaluation could examine whether firms remain registered, increase formal employment, improve financial traceability, gain access to credit, survive for longer periods, or expand their market activities after enrollment.

Interpreting the specification-sensitive results

The positive fixed-effects coefficient is an important result precisely because it encourages a more cautious interpretation of the relationship. One possible explanation is endogenous policy targeting. Tax administrations and local institutions may promote simplified regimes more intensively during periods or in locations where informality remains particularly persistent. Under these circumstances, rising RST participation could temporarily coincide with relatively high informality even if the policy contributes to improvements that become visible later.

A second explanation concerns composition. RST growth may include firms that were already registered under other tax arrangements. Such switching increases measured RST intensity without necessarily changing broader indicators of business formality. Sectoral heterogeneity may also matter. Monteiro and Assunção [13] find differences in formalization responses across economic activities in Brazil, suggesting that the effects of tax simplification may depend on business margins, labor use, and sector-specific costs.

A third possibility is timing. The RST decision can occur relatively quickly, while modifications in labor contracts, accounting practices, bank use, or firm organization may require longer periods. Consequently, quarterly first differences could capture only a small part of the adjustment process. Future research could examine distributed lags of RST intensity over several quarters rather than assuming a contemporaneous or one-quarter response.

Policy implications and future research

The findings do not imply that simplified taxation lacks policy value. Wen [2] provides a rationale for simplified taxation when compliance costs are relatively high for small enterprises. OECD et al. [8] similarly place operational simplification within a wider set of SME-development policies. The present results instead suggest that tax simplification may be most useful when it operates alongside complementary measures.

Such measures may include digital accounting support, financial inclusion, electronic invoicing assistance, management training, access to public procurement, and improved connections with formal markets. These complementary instruments can increase the economic benefits associated with remaining formal. Simplification may therefore reduce one barrier while additional policies influence whether businesses can take advantage of formal status.

Future empirical work could benefit substantially from linked administrative datasets. An ideal design would distinguish newly formalized firms from businesses that merely change tax regimes. Anonymized DIAN records could potentially be combined with RUES registration information, employment records, electronic invoicing, and longitudinal business outcomes. Such information would permit more direct analysis of post-registration trajectories and stronger identification strategies. The calibrated panel used here provides an initial framework for such work but should not be interpreted as a substitute for those administrative observations.

6. Conclusions

This study explored whether increasing participation in Colombia's Simple Taxation Regime is associated with subsequent changes in multidimensional business informality across Barranquilla, Cartagena, Santa Marta, and Valledupar. A calibrated synthetic quarterly panel covering 2021–2024 was used to examine the proposed empirical relationship through two data-verification procedures and three complementary statistical approaches. Calibration discrepancies were small, and anomaly screening identified a limited number of unusually rapid transitions. The hypothesis tests produced mixed evidence. Lagged Spearman correlations and first-difference coefficients were generally negative and therefore directionally compatible with the proposed formalization mechanism, but these estimates were imprecise. Fixed-effects models produced positive coefficients, suggesting that the relationship is sensitive to the form of within-city variation used for estimation. These results do not provide a sufficiently consistent basis for concluding that greater RST intensity is systematically associated with lower multidimensional business informality. They instead suggest that tax-regime participation, fiscal formalization, and broader organizational formalization may evolve at different rates and may be influenced by firm productivity, sector composition, local economic conditions, and selection into the regime. Future research using observed administrative data could examine these mechanisms more directly and determine whether RST enrollment is followed by measurable changes in employment, accounting practices, financial access, business survival, and other dimensions of formal economic participation.

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Ethical Statement

This study did not involve human or animal subjects. The analysis relied on a calibrated synthetic dataset constructed from publicly available aggregate statistical benchmarks.

Conflicts of Interest

The authors declare that they have no conflicts of interest involving any of the authors of this manuscript.

Authors' Contributions

Mildred Eugenia Garizabal Donado, Luz Eliana Garizabal Donado, Luis Fernando Ospino Arias, and Aydaluz Villanueva Vásquez contributed to the conceptualization, methodological design, interpretation, drafting, critical revision, and approval of the final manuscript.

Author Biographies

Mildred Eugenia Garizabal Donado is affiliated with Institución Universitaria de Barranquilla, Colombia. Her academic work is connected with business administration, innovation, taxation, and enterprise development.

Luz Eliana Garizabal Donado is affiliated with Universidad de la Costa, CUC, Colombia. Her academic work is connected with accounting and taxation.

Luis Fernando Ospino Arias is affiliated with Institución Universitaria de Barranquilla, Colombia.

Aydaluz Villanueva Vásquez is affiliated with Institución Universitaria de Barranquilla, Colombia.

Data Availability Statement

The calibrated synthetic dataset used for the statistical procedures is available from the corresponding author upon reasonable request. The annual calibration benchmarks were derived from publicly accessible aggregate information reported by DIAN and DANE. This statement is provided in accordance with the journal's data-sharing requirements.

AI Tool Use Statement

During the preparation of this manuscript, the authors used ChatGPT by OpenAI to support language editing, organizational consistency, and formatting of the abstract, main sections, tables, and references. The authors reviewed and edited the resulting content and take full responsibility for the manuscript.

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